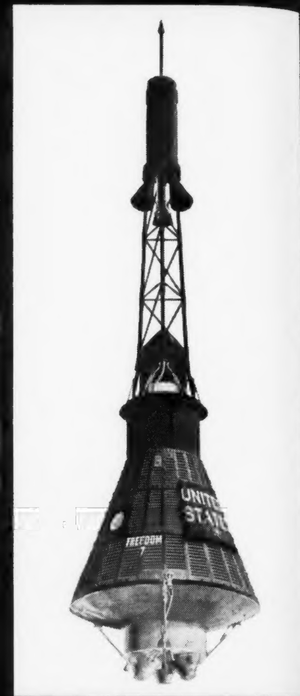
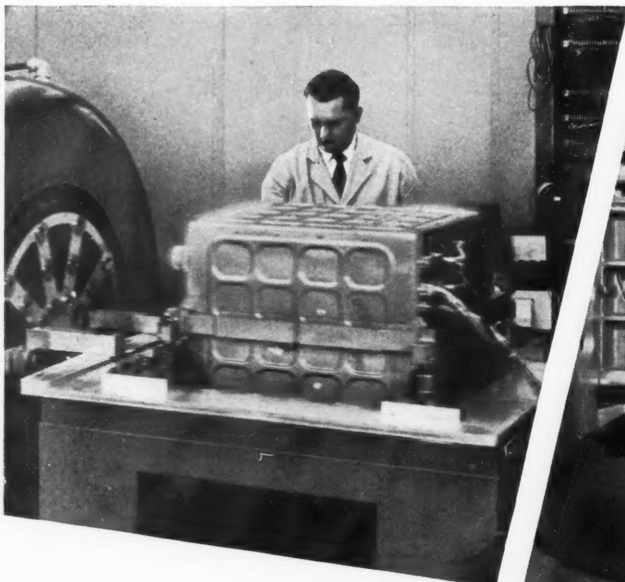
Astronautics

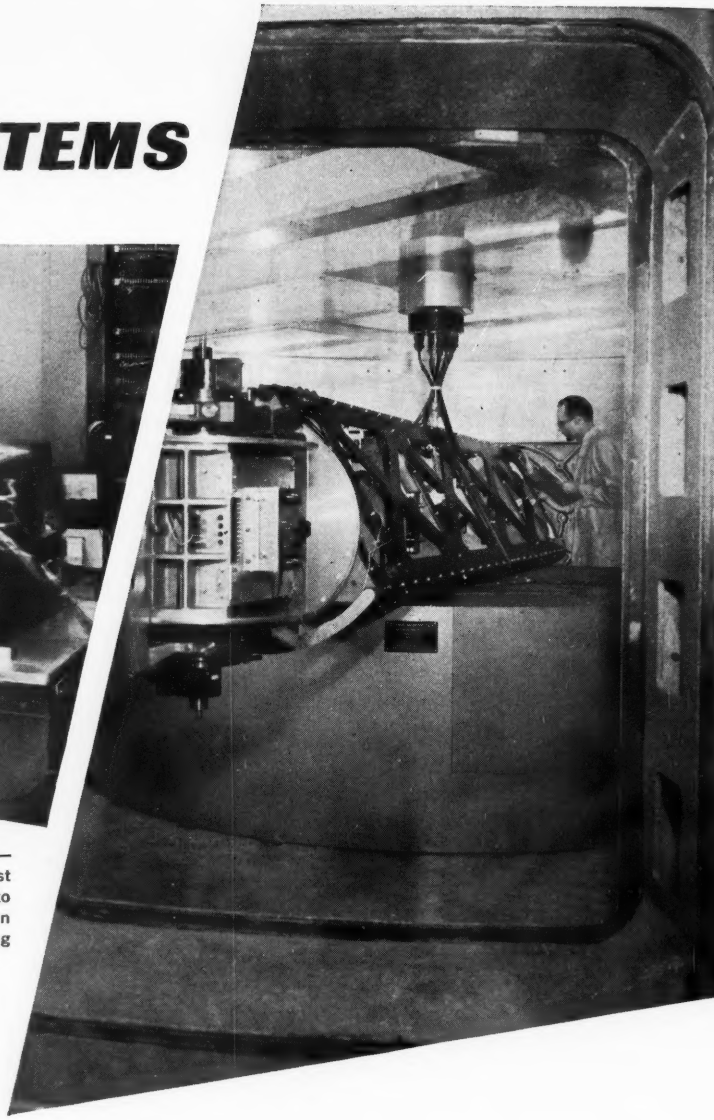
A PUBLICATION OF THE AMERICAN ROCKET SOCIETY
OCTOBER 1961

ARS SPACE FLIGHT REPORT TO THE NATION ISSUE



ARMA SYSTEMS





Vibration exciters, precision centrifuges—these are among Arma environmental test facilities used to subject weapons systems to performances far beyond actual operation—to assure reliability, accuracy and long service life.

predictable by test...proved by performance

In the receiving areas, in the materials test laboratory, on the production lines, in assembly and at the final test station... wherever you look in the Arma plant you'll see quality control and inspection equipment in use. Here rests the responsibility for maintaining the reliability of Arma systems.

And, Arma systems are famous for reliability: All-inertial guidance for the Atlas ICBM, a proved system of intercontinental range accuracy... the defense system for the B-52... shipboard fire control and navigation systems... anti-submarine warfare systems.

Arma's chief contribution to our national defense effort is the ability to deliver reliable systems—on schedule and within the budget. All research and development, engineering and production are based on that philosophy. Arma, a division of American Bosch Arma Corporation, Garden City, New York.

8268

AMERICAN BOSCH ARMA CORPORATION

COVER: This magnificent color photo of the Lagoon Nebula (Copyright: California Institute of Technology) was taken with the 200-in. Hale telescope at the Palomar Observatory using a 90-min exposure at f/3.6. The nebula, located in the Constellation of Sagittarius in the brightest part of the Milky Way, is a vast body of gas which shines by fluorescence. Ultraviolet light is absorbed by the gas and the energy reradiated in visible colors. Red is predominant because it is filtered through great amounts of dust. (ASTRO cover plaques 11 x 12 in. are available from ARS Headquarters at $2.00 each.)

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY INC.

Vol. 6 No. 10 October 1961

EDITORIAL

IMPLICATIONS OF SPACE FLIGHT

SPACE FLIGHT REPORT TO THE NATION

EDUCATION

DEPARTMENTS

BPFA

Published monthly by the American Rocket Society, Inc., and American Interplanetary Society, Inc., at 20th & Northampton Sts., Easton, Pa. Editorial offices: 500 Fifth Ave., N. Y. 36, N. Y. Subscription price: $9, foreign $9.50 per year. Single copies, $1.50. Second-class postage paid at Easton, Pa., with additional entry at New York, N. Y.

Astro notes

MAN IN SPACE

• Remember, writing in the June *Astronautics,* NASA's William Fleming mentioned that the loss of at least one major launch vehicle and payload had been traced to a loose piece of solder in a diode, and that investigation of the manufacturer's diode inventory uncovered a lot of diodes similarly faulty? Dust-like solder particles in diodes caused the postponement of the Atlas-D scheduled to launch a Project Mercury capsule (MA-4) on its first unmanned orbital flight.

• Atlas-D autopilot-programmer combinations failed repeatedly in checkouts at Cape Canaveral during preparations for MA-4, despite the fact that they worked properly in qualification tests at GD/Astronautics. A series of autopilot-programmers had to be returned to San Diego—transactions which resulted in some high-spirited coast-to-coast conversations. Finally, a systematic examination of the autopilot-programmer discovered the defective transistors, just as MA-4 went through its countdown with an apparently qualifying autopilot aboard. News of the defect reached the Cape in time to cancel M-4 and flight tests of two Atlas missiles on nearby pads.

• Things were set aright by Sept. 13 when NASA successfully orbited and returned MA-4 after one circuit of the earth. A destroyer picked up the capsule 1 hour and 10 min after it landed 161 mi. east of Bermuda. The capsule equipment, including devices simulating an astronaut, functioned well, except for an inverter failing and the main oxygen supply draining too rapidly.

• Plans now call for a three-orbit mission with the capsule carrying a simulated astronaut or a chimpanzee. This flight would be followed as soon as possible with a manned one. NASA Administrator James Webb expressed some confidence that a manned Mercury orbital flight might be attempted before the year's end.

• On Sept. 1, after 33 revolutions of the earth, Discoverer XXIX returned from orbit a capsule of biological specimens prepared by the School of Aviation Medicine. The capsule carried a three-day-old embryonic chick heart, human amnionic cells, batches of human bone-joint and bone-marrow cells, influenza (from cultured batch of first-strain ever isolated) and entero viruses, the soil bacteria *clostridium sporogenes,* and several radiation dosimeters. John E. Prince heads the research team working with the specimens.

• A small self-maneuvering space-pack for an astronaut working outside a space vehicle and an emergency-escape system for space vehicles that would sense failures and initiate escape procedure are being investigated by Chance-Vought-Astronautics for the AF under some $135,000 in contracts.

• After two years of on-and-off status, the AF finally abandoned its plan to orbit and recover a small rhesus monkey in a Discoverer capsule. It said that flight of the monkey would not contribute significantly to the U.S. space program, and added that NASA is responsible for bioastronautic studies. Plans to orbit a monkey were revealed in 1959 by former ARPA Director Roy Johnson, but the project was never carried out because it was not connected to a specific AF mission. NASA plans to orbit a chimpanzee as part of its Mercury program, and it is also devising a special Mercury capsule for week-long flights of monkeys and mice.

• In a further revelation of his space flight experiences, Russian Cosmonaut Gerhman Titov disclosed that he dined upon liquid foods squeezed from tubes during his 17 circuits of the earth. His first meal included a soup puree, a meat and liver paste, and currant juice. At one point, some of the currant juice escaped and formed blackberry-like clusters before his face. "They remained suspended in the air scarcely quivering," Titov wrote in Pravda. He reported that he scooped them up in the top of his food tube and swallowed them.

SPACE PROBES AND SATELLITES

• The U.S. may yet have a chance of entering a scientific payload in the race to Venus next August, but it will not be the 1150-lb Mariner spacecraft under development at NASA's Jet Propulsion Laboratory. Development troubles have postponed the initial flight test of the Atlas-Centaur until some time in 1962, so that it will not be available for the Venus attempt, and probably not for an attempt to reach Mars in November 1962. The next best launching vehicle appears to be Atlas-Agena-B, which can place approximately 700 lb in an escape trajectory. This means that the Ranger lunar spacecraft will likely be adapted for Venus and Mars fly-bys next year.

• NASA hopes to launch Ranger II on a deep-space trajectory this month. The failure of the Agena-B stage to send Ranger I on its planned path deep into space was gall and salt. Ranger I remained in its near-earth "parking orbit" and attempted to carry out its complex program, which included acquisition and locking on to the sun as well as location of the earth with its directional antenna. Although the spacecraft squirted away its compressed nitrogen at an excessive rate during each dark passage, in a futile effort to locate the sun, the JPL design group was generally happy with the spacecraft's performance. Ranger I fell into the dense atmosphere and burned up six days after launching. It supplied little useful scientific information.

• In another move to support the U.S. manned lunar-landing program, NASA ordered four additional Ranger spacecraft to obtain high-resolution TV pictures of the lunar surface up to the moment of impact. This raises to nine the number of Rangers now on order and to seven the number to be aimed at the moon. The first three of these will attempt to hard-land instruments on the moon. No attempt will be made to brake the remaining four Rangers. RCA's Astro-Electronics Div. will develop the TV systems.

• Astronomers attending the recent International Astronomical Union at Berkeley, Calif., proposed the development of a space probe capable of intercepting Encke's Comet in 1964 at a distance of 25-million mi. from the earth. The probe would take pictures of the comet's hard core. Although the head of the comet is 60,000 mi. in diam, its core of frozen gases and dust is

(CONTINUED ON PAGE 10)

A New Achievement in Precision Controls for Space Application

Marquardt Documents 1,000,000th Pulse of Radiation Cooled Bipropellant Rockets

A three year research and development program directed at advanced space propulsion and control systems reached a significant milepost on September 8 when The Marquardt Corporation documented the 1,000,000th re-start of radiation cooled bipropellant pulse rockets. These rockets, operating at pulse frequencies up to 100 cycles per second, demonstrated that combined response and delay times of .006 second and effective pulse widths of .003 second are now attainable. Development to reduce these times is currently in progress.

Typical of Marquardt's pulse rocket development in the range of 0.2 to 100 lbs. thrust is a 25 lb. thrust rocket for a current satellite propulsion requirement. *This engine demonstrated an intermittent operational life of over 50 minutes at rated thrust, and has achieved a remarkable 46 minute continuous run.* At the end of the test, there was no evidence of system deterioration. This type of rocket engine has repeatedly demonstrated a space Isp of 310 seconds using hydrazine and nitrogen tetroxide as propellants.

Coupled with Marquardt's secondary injection, gimballing techniques, and throttleable rockets, these pulse rockets make possible a range of control systems that can meet the most advanced space control requirements. In a complex lunar landing-return mission, a Marquardt system can provide main course velocity control, orbital ejection-injection, descent-ascent control, and lunar circumnavigation.

Marquardt's sixteen years of research and development in controls have led the company into many pioneering areas in the aerospace field. In variable thrust engines, Marquardt rockets, using storable liquid propellants, proved an average C* efficiency of 95% over a wide throttling range. Successful investigations and developments have been achieved in injectants for thrust vector control, including tap-off of hot gases from the primary combustion chamber, cold gases such as nitrogen or air, non-reacting liquids such as freon and reacting liquids such as hydrazine.

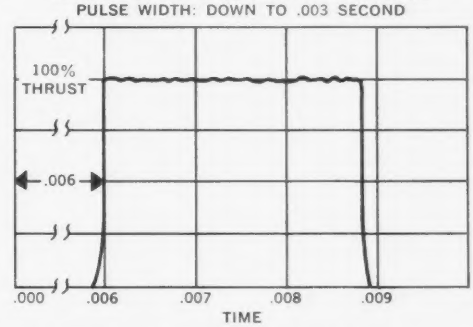
The Marquardt Corporation today provides the aerospace industry with one of the most extensively documented records in the area of space propulsion controls systems and components. Be it part or package, Marquardt can prove a record of performance which insures reliable products delivered on time and at minimum cost. For additional information contact R. L. Oblinger, Chief Application Engineer, Power Systems Division.

Engineers experienced in these or related fields will find it rewarding to discuss career futures with Marquardt — an equal opportunity employer.

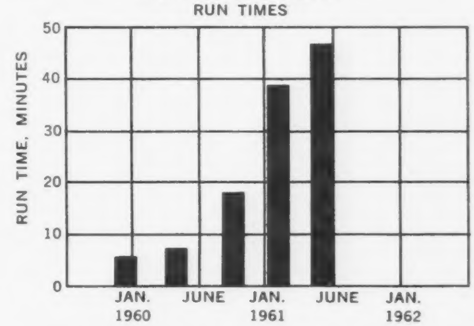
THE *Marquardt* CORPORATION

CORPORATE OFFICES: VAN NUYS, CALIFORNIA

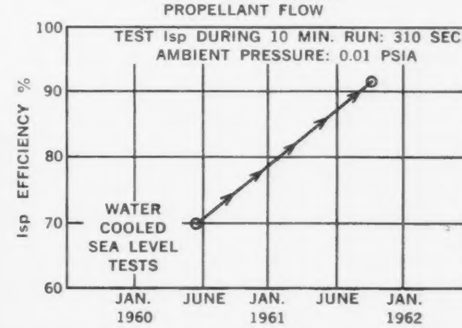
ASTRO ◆ OGDEN DIVISION
◆ POMONA DIVISION
◆ POWER SYSTEMS DIVISION



DOCUMENTED IMPULSE CAPABILITY
The above trace represents one impulse bit — demonstrating controllability of pulse width down to .003 second.



RADIATION COOLED THRUST CHAMBER RUN
Continuous 46 minute run duration of radiation cooled thrust chamber with N_2H_4 and N_2O_4 demonstrated a 90% efficiency with no degradation in performance during run and showed no adverse effects on the system.



DEMONSTRATED Isp EFFICIENCY
This chart shows thrust efficiency increase over slightly more than two years. Latest tests prove an Isp of 310 seconds, during a ten minute run at 0.01 PSIA.

Key number 3

estimated at only 1 mi. in diam. The scientists would like the probe to come within 10,000 mi. of the core and take pictures with a 40-in.-long camera for relay to the earth. Task of intercepting a comet is considered many times more difficult than that of meeting a planet because the relative velocity at conjunction could be 50,000 mph or more.

• An AF Blue Scout Junior, with a 27-lb radiation-detecting payload, was launched into a 140,000-mi. loop trajectory in August, but all telemetry failed after fourth-stage ignition. It was the seventh Blue Scout Junior fired in the development series, with four more scheduled this year. AF credits itself with five successes and two failures in the Blue Scout program to date, but it is evidently considering only vehicle performance in this appraisal. Six of the Blue Scouts have been similar to NASA's Scout, while one has employed only three stages.

• E. R. Mustel of the USSR Astronomical Council reported that proton counters aboard the Russian Venus probe measured a maximum of only 20 protons per cubic centimeter at the low energy levels estimated for the hypothesized "solar wind." His finding is in line with observations of about 40 ions per cubic centimeter by the U.S. P-14 space probe last spring. Scientists in charge of that experiment believe they found evidence of solar wind carrying the sun's magnetic field out beyond the earth. The Soviet findings suggest, to the contrary, that any steady solar wind must be quite feeble, although sporadic bursts of plasma may boost it.

• NASA rang up a decisive success with Explorer XII, the first of its series of four energetic-particle satellites. The 83-lb package was hurled into a 26.4-hr orbit with an apogee of 47,800 mi. and a perigee of 180 mi., permitting it to measure both of the Van Allen Belts as well as the edge of interplanetary space, where solar wind and plasma are believed to interact with the earth's magnetic field. It was the fifth success out of six tries for the Thor-Delta booster vehicle, giving it the best batting average of any U.S. vehicle to date. Scientists of NASA's Goddard SFC reported they were receiving a torrent of real-time information from the six groups of radiation and magnetic experiments in the satellite.

• Somewhat less successful was Explorer XIII, a 175-lb micrometeoroid satellite launched by a four-stage Scout from Wallops Island, Va. It was the fourth orbital attempt for Scout (and the second try with the micrometeoroid payload) and it succeeded in achieving an orbit of two days' duration. The abrupt demise of the package, the most elaborate cosmic-dust experiment to date, was something of a mystery. Goddard SFC had reported that the satellite was in a 97-min. orbit with an apogee of 606 mi. and a perigee of 174 mi., but it became apparent that the perigee was very much lower than initially computed. NASA engineers tentatively blame an aiming error in the spin-stabilized X-248 Altair fourth stage of Scout.

• The Weather Bureau and NASA have invited 100 nations to send representatives to an International Meteorological Satellite Workshop to be held Nov. 13–22 in Washington, D.C. This workshop will be devoted to a series of short lectures on the engineering aspects of Tiros satellites, significant research results, data acquisition, and program plans for future weather satellites. Participants will have an opportunity to prepare weather analyses from satellite photographs and will witness the actual operation of the Tiros ground system if a Tiros satellite is in operation at the time of the meeting.

SPACE TECHNOLOGY

• Astronomers at the International Astronomical Union meeting bitterly attacked the AF plan to project some 75 lb of copper dipoles into a polar orbit. They warned that the belt of whiskers would attenuate and reflect light and radio energy coming in from the cosmos, despite assurances from some U.S. groups that the initial belt will be far too tenuous to have a perceptible effect on astronomy. It was apparent that the astronomers were really concerned about the consequences of future belts involving several tons of dipoles, and they feared that the initial belt would create a strong precedent for denser belts. It was also apparent in Washington that the AF intended to go ahead with the project, known as West Ford, after finally receiving a blessing from Jerome Wiesner, the President's science adviser.

• Liberal members of Congress continued to roast the Administration and the FCC for offering the U.S. communications satellite program exclusively to the common carriers. In a letter to President Kennedy, 35 Democrats in the Senate and House protested that the FCC plan would give American Telephone & Telegraph a dominant position. "In effect, AT&T would be the chosen instrument of the United States Government to own and control civilian space communications," they wrote.

• NASA selected Blaw-Knox Co., Pittsburgh, Pa., to conduct a $250,000 "second phase study" on the design of a 240-ft antenna for JPL's Goldstone DSS. The Blaw-Knox feasibility and design study is to be completed by mid-1962, with the system operational at Goldstone by 1965. The 240-ft dish will provide a tenfold performance increase over the existing DSIF, which consists of 85-ft antennas at Woomera, Goldstone, and Johannesburg.

• GE will build six fourth-stage payload capsules for the Trailblazer II re-entry studies being conducted for ARPA by MIT's Lincoln Laboratory at Wallops Island, Va. GE's stage measures 2 ft in length and weighs 30 lb, including the plastic ablation shield, electronics package, and the unfueled rocket motor. The multistage Trailblazer II will reach 190-mi. altitude, followed by downward firing to speeds up to 17,000 mph. The vehicles will be observed by radar and optical devices during re-entry.

• The AEC will develop a 25-watt radioisotope generator for NASA's Surveyor lunar soft-landing program. The Surveyor is deemed an optimum customer for an isotope generator because half of its operating lifetime on the moon will be spent in darkness. The Surveyor generator, which will use thermoelectric conversion, will be fueled by Curium-242, an alpha-particle emitter produced by irradiation of another man-made element, Americium-241, in a nuclear reactor.

• The Navy successfully air-launched a two-stage unguided Sparoair rocket with a 35-lb payload of telemetry apparatus to an altitude of 64 mi. Sparoair measures 12 ft long and 8 in. in diam. It includes two Sparrow missile motors. This first launching, made from an F4D aircraft at an altitude of 33,000 ft over the Pacific Missile Range, will be followed by nine more flight tests.

• Meantime, the AF disclosed it

(CONTINUED ON PAGE 16)

CONVAIR/POMONA USES

DORSETT TELEMETRY COMPONENTS

Subcarrier oscillators designed and built by Dorsett Electronics are standard equipment in the FM telemetry systems of both the Advanced Terrier and the Tartar missiles, built by Convair/Pomona, Convair Division of General Dynamics.

The same high standards of electrical performance and quality workmanship that go into the telemetry components being delivered to Convair/Pomona are found in all Dorsett-built telemetering equipment. That is why more and more of the nation's missile and satellite builders are specifying Dorsett equipment.

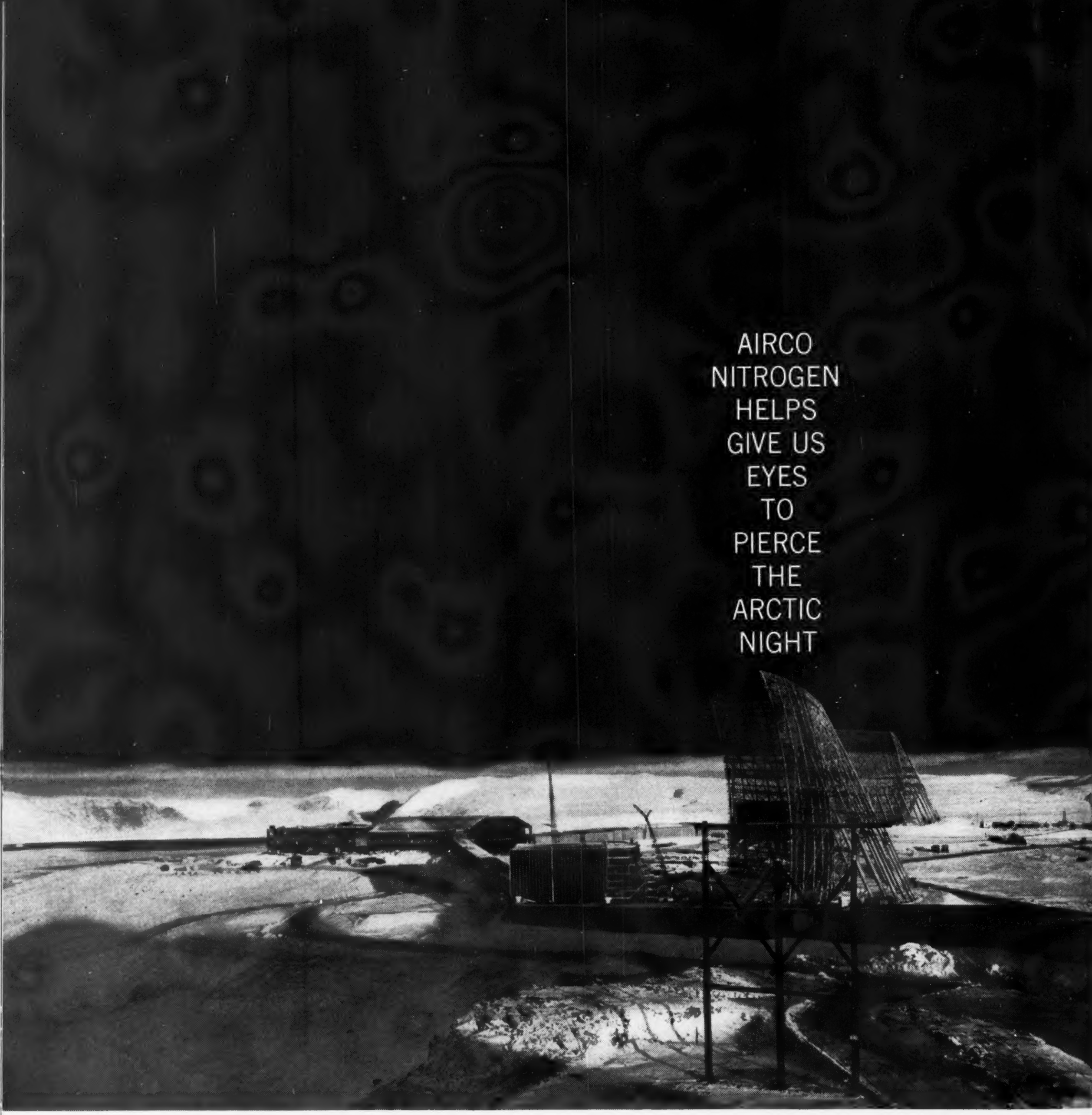
For more information on the products and capabilities of this fast growing team of telemetering specialists, including the new facilities at Dorsett's West Coast Division—American Missile Products Co., Inc., write today.

D

DORSETT ELECTRONICS, INC.

P. O. BOX 862 • NORMAN, OKLAHOMA • PHONE JE 4-3750

Key number 4



A giant BMEWS antenna at Thule, Greenland. Vital diode crystals for the data processor were grown in an atmosphere of Airco nitrogen, monitored by an Airco-engineered system.

Faultless eyesight for America's Ballistic Missile Early Warning System depends on germanium diodes—tiny signal filtering "optics" for the data processor which are made by Clevite Transistor, Waltham, Mass. These germanium crystals are grown in a furnace atmosphere of nitrogen, and they must be of the highest quality.

Control of this quality in diode manufacture requires that the delivered gas be of utmost purity; and that this purity be held all the way from the liquid nitrogen receiver to furnace. An impurity of even a few parts per million in the nitrogen, and entrapped in the furnace-grown crystal, could cause miles of error in a field calculation.

To help make certain of the highest possible quality at the lowest possible cost, Clevite developed a gas monitoring system which Airco engineered and built to Clevite's specifications. The resulting system is so precise that it keeps watch on the purity of the Airco nitrogen right to the furnace entrance.

In every industry today, modern Airco processes based on gases are improving quality, boosting production, reducing costs.

Airco gases can give you heat...cold...special atmospheres . . . or can act as a raw material for a chemical reaction.

AIRCO

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated

150 East 42nd Street, New York 17, N. Y.

More than 700 Authorized Airco Distributors Coast to Coast

On the west coast— Air Reduction Pacific Company
Internationally— Airco Company International
In Canada— Air Reduction Canada Limited
All divisions or subsidiaries of Air Reduction Company, Inc.

Key number 5

has abandoned a similar program of its own after two test flights. This was the Jaguar system, devised for air-launch by B-57 aircraft. It said one of these attained an altitude of 600 mi. The program was dropped, the AF said, because the radiation studies planned for the rockets were completed with other vehicles.

LAUNCH VEHICLES

• The first Saturn flight test may come this month. The first booster arrived by barge at Cape Canaveral on Aug. 15, and since then preparations for a launching have been moving at top speed.

• Besides its $100,000 study contract with NASA-Marshall, the Boeing Co. has received a $378,000 AF contract to study problems in the development of boosters with thrusts from 1- to 9-million lb. The program will define problem areas associated with propellant-feed systems, propellant tankage, tank pressurization, and the interaction of these with auxiliary power systems. The AFSC 6593 Test Group at Edwards AFB monitors the Boeing contract. Glen Hanks and D. E. Serrill head the Boeing work.

• After an intensive survey of potential U.S. launching sites, NASA selected the area north of Cape Canaveral for firing advanced Saturn and Nova rockets on manned Apollo missions to the moon. It announced a $60-million program to buy 80,000 acres of land on the north of Merritt Island, to the north and west of the AF's 17,000-acre installation on Cape Canaveral. The huge increases in operational area will be necessary because noise and blast effects from Nova boosters, some of which may range up to 20-million-lb thrust, will require buffer zones of up to 10 mi. Construction of launch complexes should commence in 6 to 12 months in order to meet the lunar-flight target date, NASA said.

• NASA expects to select a contractor for the Rover rocket vehicle early in 1962, according to Administrator James Webb. To date, Aerojet-General has been selected as contractor for the Rover reactor-engine combination, designated Nerva. Initial flight test for Rover is scheduled for the 1966–67 period, but Glenn Seaborg, chairman of the AEC, believes this date might be advanced to 1965 if the upcoming series of Kiwi-B reactor tests show outstanding success. First of these, using gaseous hydrogen, is scheduled for this month at the Nevada Test Site, with liquid hydrogen to be used in the second test early in 1962.

• Despite prodding from members of the Joint Atomic Energy Committee, Webb resisted suggestions that the Rover system be included as an upper stage in the manned lunar mission. Krafft Ehricke, Centaur program director for GD/Astronautics, strongly favored a lunar mission for Rover. He proposed that NASA settle on a 6-million-lb-thrust Nova booster based on four F-1 engines and a second stage of four J-2 lox-hydrogen engines generating 800,000-lb thrust. A Rover third stage of 50,000-lb thrust would permit this vehicle to land on the moon and return a 17,000-lb capsule to earth. In the event the nuclear stage could not be realized soon enough, two all-chemical Novas could carry out a single orbital rendezvous to assemble a vehicle capable of the lunar mission.

• Ehricke was critical of NASA's proposals for all-chemical systems large enough to accomplish a direct lunar-landing mission because he believes these will take longer to develop than a chemical vehicle using a nuclear upper stage or orbital rendezvous to carry out the Apollo-C landing mission.

• The basic building block of Ehricke's ambitious plans—the Rocketdyne 1.5 million-lb-thrust F-1 engine—failed on its first public static firing at Edwards AFB, Calif. Scheduled to develop full thrust for a duration of 20 sec, the unit actually operated for only 1.5 sec. Automatic shutdown resulted when vibration damaged a small electrical switch on a fuel valve.

• NASA's Marshall SFC negotiated an 18-month $993,559 contract with RCA's Astro-Electronics Div. for development of a payload capsule tailored to carry two small ion engines on a Scout-launched test flight late next year. The flight should reach an altitude of 4000 mi. and last about 70 min. This would allow sufficient time to test the thrust levels of the two motors, which are rated up to 0.01 lb thrust. As many as 10 flights may be made in the program.

• Rocketdyne's R&D Vice-President Thomas F. Dixon assumed his duties as director of NASA's Office of Launch Vehicle Programs in mid-September.

• Vitro Engineering Co. has been selected by the joint NASA-AEC Space Nuclear Propulsion Office from among 20 firms for negotiation of an architectural and engineering design contract for a nuclear-engine maintenance and disassembly building, which will constitute the first component of the National Nuclear Rocket Development Center, probably to be located at the AEC's Jackass Flats test site in Nevada. The National Nuclear Rocket Development Center will be a facility of the joint NASA-AEC Office headed by Harold Finger.

• Some $900,000 worth of Arcas sounding rockets will be built by Atlantic Research under a new ONR contract, which also represents support from the AF and Army. The new contract will speed the wide application of Arcas.

• Under an AF contract for $882,000, GE's Missile and Space Vehicle Dept. will develop a capsule for testing a 50-w fuel-cell battery in a 300-mi. orbit for a nominal period of 30 days. The fuel-battery will be designed and developed by GE's Aircraft Accessory Turbine Dept. at Lynn, Mass. It will consist of 30 individual cells, and will have an output of 6 or 28 v.

WEAPONS

• The Minuteman ICBM exploded on maiden launch from an underground silo at Cape Canaveral, Fla. The AF reported that the silo and launch facility were not damaged by the malfunction and expressed confidence the launch schedule would be met.

• Meantime, it appeared that the U.S. would soon commence tests to upgrade the yield of the Minuteman's thermonuclear warhead from an estimated one-half megaton to a level of one megaton. These are presumably to be conducted underground at the Nevada Test Site as part of the new round of U.S. tests in response to the Soviet Union's resumption of tests.

• The Martin Co. announced it will deliver 424 Bullpup trainer missiles to the AF under a $1.5-million contract. The trainer utilizes the obsolete HVAR engine in place of the Bullpup's more expensive motor, weighs only 125 lb to 600 lb for the operational Bullpup. Nevertheless, it incorporates enough performance to acquaint a pilot with actual operation. ♦♦

Bell's HIgh PERformance NAvigation System — symbolized.

HIPERNAS!

It can pinpoint a long-range missile on target. Guide a satellite or space ship to any point in the universe. Regulate the predetermined course of a surface vessel or submarine to any spot on the seven seas — by any route, however circuitous.

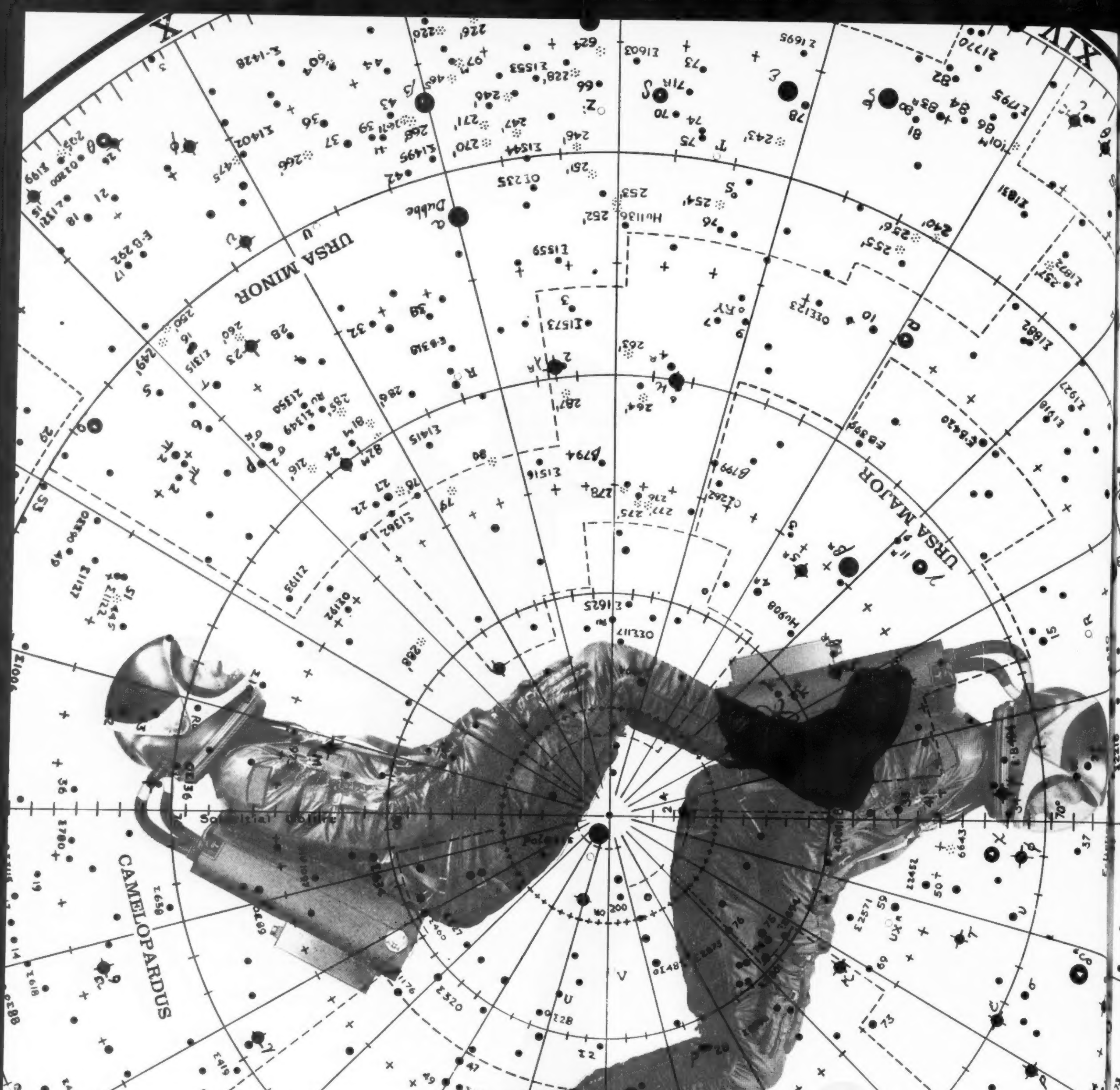
In manned vehicles, it will give exact position — even without an atmosphere — independent of gravity, sea, wind, and weather conditions — without fixes on horizon or stars — after days and weeks of travel.

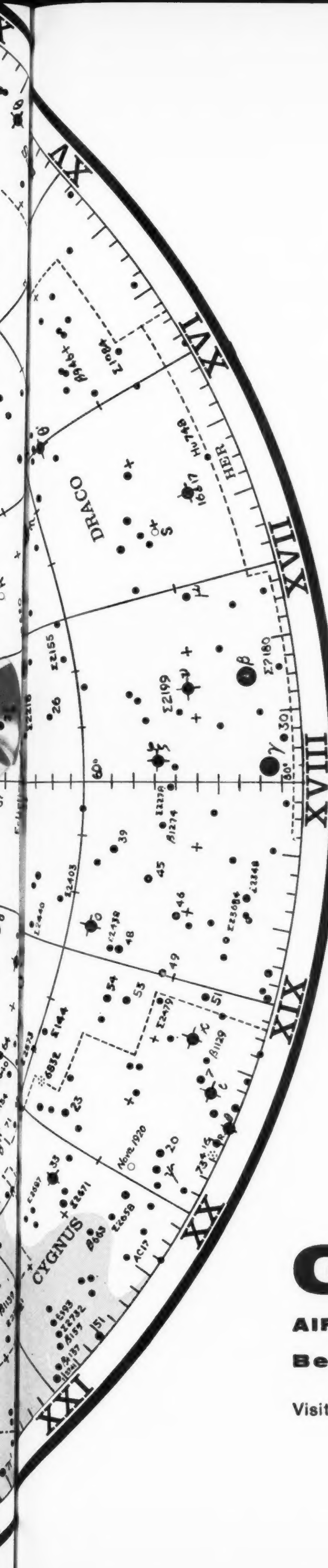
This is **Hipernas,** a self-compensating, pure inertial guidance system developed by Bell's Avionics Division. Designed for the U.S. Air Force, **Hipernas** is so versatile that a whole family of related systems has been engineered for application in any environment — sea, sky, or space.

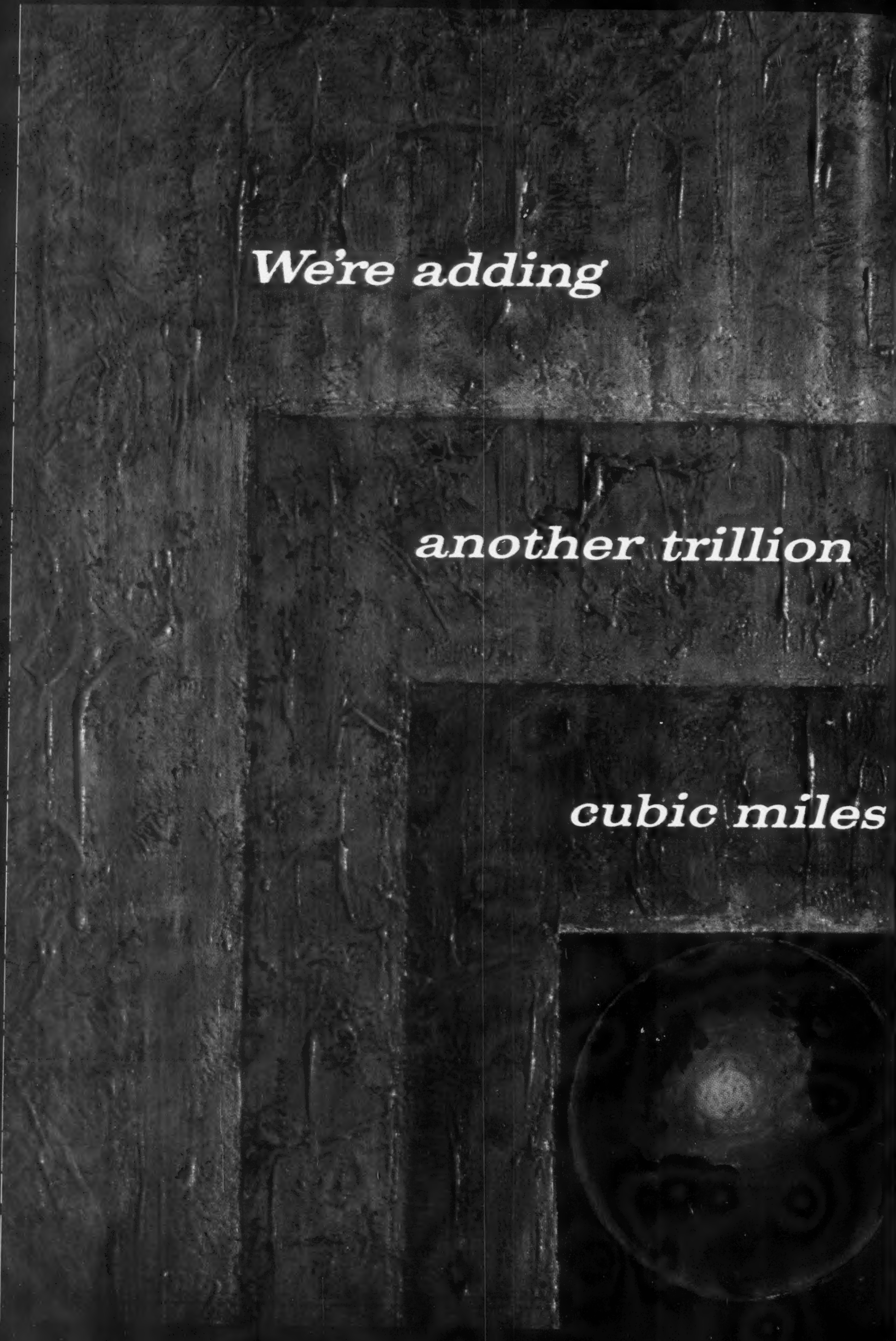
The system introduces new Bell BRIG gyros. Its accelerometers and digital velocity meters are already operational in missile and space guidance systems.

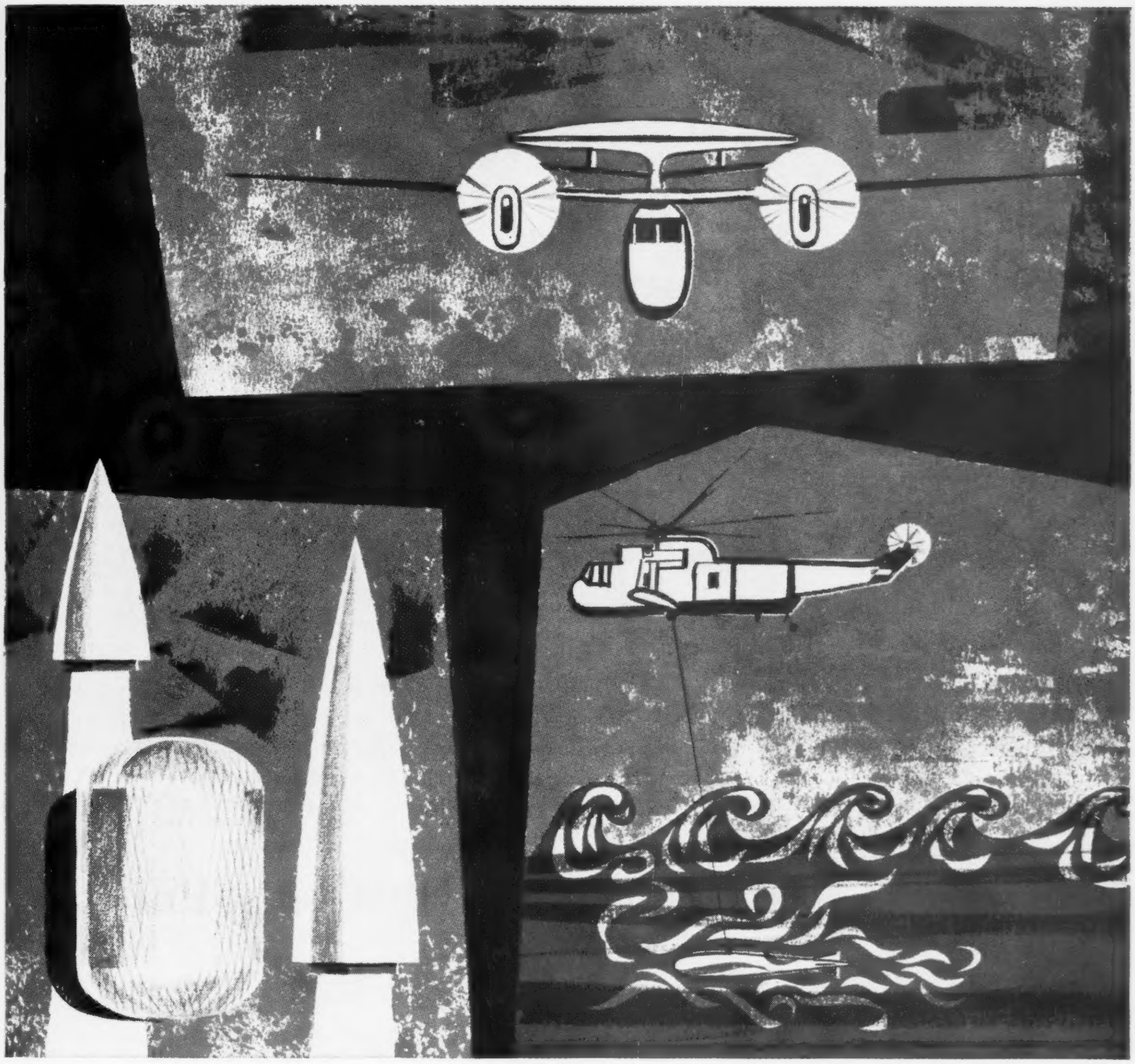
Hipernas — and many other systems such as the Air Force GSN-5 and the Navy's SPN-10 All-Weather Automatic Landing Systems — typify Bell's capabilities in the broad field of electronics. This diversity of activities offers an interesting personal future to qualified engineers and scientists.

BELL AEROSYSTEMS COMPANY
BUFFALO 5, N. Y.
DIVISION OF BELL AEROSPACE CORPORATION
A TEXTRON COMPANY


URSA MINOR
URSA MAJOR
CAMELOPARDUS
CEPHEUS
Equinoctial Colure
CASSIOPEIA
PERSEUS
LACERTA
ANDROMEDA
Nova 1572


XV
XVI
DRACO
HER
XVII
XVIII
XIX
XX
CYGNUS
XXI


We're adding
another trillion
cubic miles



Aerojet General's restartable Ablestar upper stage uses three titanium pressure bottles for a weight-savings of 60 pounds. The nozzle extension is also titanium.

How Titanium pressure bottles reduce missile weight

Trend based on metal's high performance, fabricability and immediate availability suggests retrofit applications

The swing to light-weight, high-strength titanium metal for pressure bottles in the current generation of liquid-fueled missiles provides conclusive proof of the design advantages and reliability inherent in titanium construction. (See box score)

This state-of-the-art report, prepared by Titanium Metals Corporation of America, outlines performance, price and fabrication histories of the Ti-6A1-4V grade as attested to by those who know the metal best—the firms that realize its benefits most.

Titanium's performance history may thus chart a path to important weight reductions in space probes, as well as in orbital vehicles and manned missiles. Titanium pressure bottles are now solving weight and reliability problems in complex pressurization, restart, actuation and stabilization devices.

Suggested also by this trend are a number of retrofit applications of titanium pressure bottles in aircraft . . . cockpit pressurization, ejection, and other pneumatically controlled and actuated systems.

HIGH STRENGTH-TO-WEIGHT RATIO The metal's most important attribute can be summed up in a few words . . . *titanium is 44% lighter than steel at the same strength*. In addition it has . . .

RELIABILITY AT CRYOGENIC TEMPERATURES Unlike many metals, titanium retains good mechanical properties as the temperature drops. Titanium pressure bottles have shown high strength, ductility, impact resistance and low notch sensitivity at temperatures below *minus* 300F and working pressures up 9,000 psig. *There is no evidence of a single failure in service.*

MECHANICAL PROPERTIES According to Mr. Abe Hurlich, Supervisor, Materials Research Group, Convair-Astronautics Div., General Dynamics Corp., Ti-6A1-4V vessels display the following mechanical properties (note especially retention of ductility):

VISIT EXHIBIT BOOTH 254 AT ARS SPACE FLIGHT REPORT

BOX SCORE ON TITANIUM PRESSURE BOTTLES

60 pounds saved in Ablestar First successful rocket engine to be restarted in space uses three spherical titanium pressure bottles to hold helium at 4,350 psig for the pressure feed system. According to Aerojet Spacecraft Division, Aerojet General Corporation, designers and builders of Ablestar, the titanium (Ti-6Al-4V) pressure bottles saved a total of 60 pounds over steel.

Titan losing 150 pounds Martin Company reports that it is in the process of switching from aluminum to titanium (Ti-6Al-4V) bottles and is saving 150 pounds in each missile! Four spherical bottles, containing helium, furnish pressure for fuel and LOX systems. Two are used in each stage and are contained inside the LOX tank. In addition to high strength-to-weight ratio and cryogenic properties, Martin listed the "availability" of titanium pressure bottles as a factor in the change.

High performance dictates titanium in Agena Lockheed Aircraft Corporation reports that titanium's high performance, as well as its light weight, was important in the choice of Ti-6Al-4V alloy for spherical helium pressure bottles used in Agena "A", satellite for the "Discoverer" program. An average of 8 pounds per bottle were saved, according to Lockheed engineers. From three to five bottles, depending on the program, are used as reservoirs for the cold gas reaction jets in the stabilizing system.

325 pounds saved in X-15 Four Ti-6Al-4V titanium bottles that store helium at 3,800 psig are used in the X-15 "manned missile," for a weight-savings of 325 pounds over the original Inconel X bottles. A 96" x 14" cylindrical bottle operating at –300F, pressure feeds LOX and ammonia to the engine through a reducing valve. Three spherical bottles pressure-feed hydrogen peroxide to the engine, pneumatically control propellant system valves, and purge the engine for restarts.

Pioneered on Atlas; saves 129 pounds per bottle The titanium pressure bottle was developed to a practical reality on Convair-Astronautics' Atlas. The original stainless steel sphere weighed 205 pounds. The Ti-6Al-4V titanium sphere, heat-treated to 160,000 psi, weighs 75 pounds! Design burst pressure is 5,000 psig at ambient temperature. Actual burst pressures at –320F have been consistently at 9,000 psig and higher.

Mechanical properties: Ti-6Al-4V pressure vessels

	TEST TEMPERATURE 70 F	minus 320 F
Yield strength (0.2% offset)	137,000 psi	229,000 psi
Tensile strength	156,000 psi	236,000 psi
Elongation	16%	11%
Reduction in area	52%	36%
V-Notch Charpy impact energy*	17.5 ft-lb	10.0 ft-lb

*Double width, half-thickness specimen with one-half the standard depth notch.

CORROSION RESISTANCE Titanium's well-known resistance to corrosion is another reason for the metal's growing history of reliability under extreme environmental conditions.

FABRICABILITY—WHAT THE FABRICATORS SAY Most current pressure bottles are being made of Ti-6Al-4V, an alloy heat-treatable to 160,000 psi minimum (on a strength/weight basis, this is equal to steel at 280,000 to 300,000 psi). Construction usually consists of hemispherical forgings machined to precise contours, girth welded and heat treated.

Here are reports from fabricators who helped develop the titanium pressure bottle.

Airite Division of the Electrada Corporation, Los Angeles, California, says, "Titanium can be forged and machined as accurately as steel. We are easily obtaining surface finish of 100 microinches and holding contour and wall thickness to plus or minus 0.005 inches."

Menasco Manufacturing, Burbank, California, reports, "We prefer to use it. Titanium is now as reliable as any other metal and has probably a lower rate of reject. After good fabrication procedures are established, old wive's tales are soon dispelled."

AVAILABILITY AND LOWERING COST The development phase for titanium pressure bottles is now over. Fabricators are producing them on a production line basis. The titanium industry can easily produce the Ti-6Al-4V grade required for the solid and liquid fueled programs in design or development, with capacity now in place. Lead-times are generally short, with TMCA warehousing large stocks of the alloy in Toronto, Ohio and Los Angeles for 24-hour shipment.

Prices of the Ti-6Al-4V grade and fabrication costs have diminished steadily: Metal costs have declined 62.4% since 1955; unit price of the titanium pressure vessels employed in the Atlas has dropped 30% since their first use; a rocket case fabricator recently quoted the steel-titanium price differential at 15%, with the titanium case weighing about 40% less than the steel version.

With materials and fabrication costs amounting to only 13% of the total price of any missile system, designers are growing reluctant to concede quality in the actual vehicle. Titanium, accordingly, suggests serious consideration *today*.

HOW TO USE TMCA INFORMATION RESOURCES If you are now fighting a weight bogey on an assembly that requires structural strength at temperatures between minus 320F to plus 1,000F, while retaining corrosion immunity . . . or if you need information on titanium fabrication . . . missiles applications . . . competent fabricators . . . a letter to TMCA's Technical Service Department would probably go a long way to solving your problems. Why not write today?

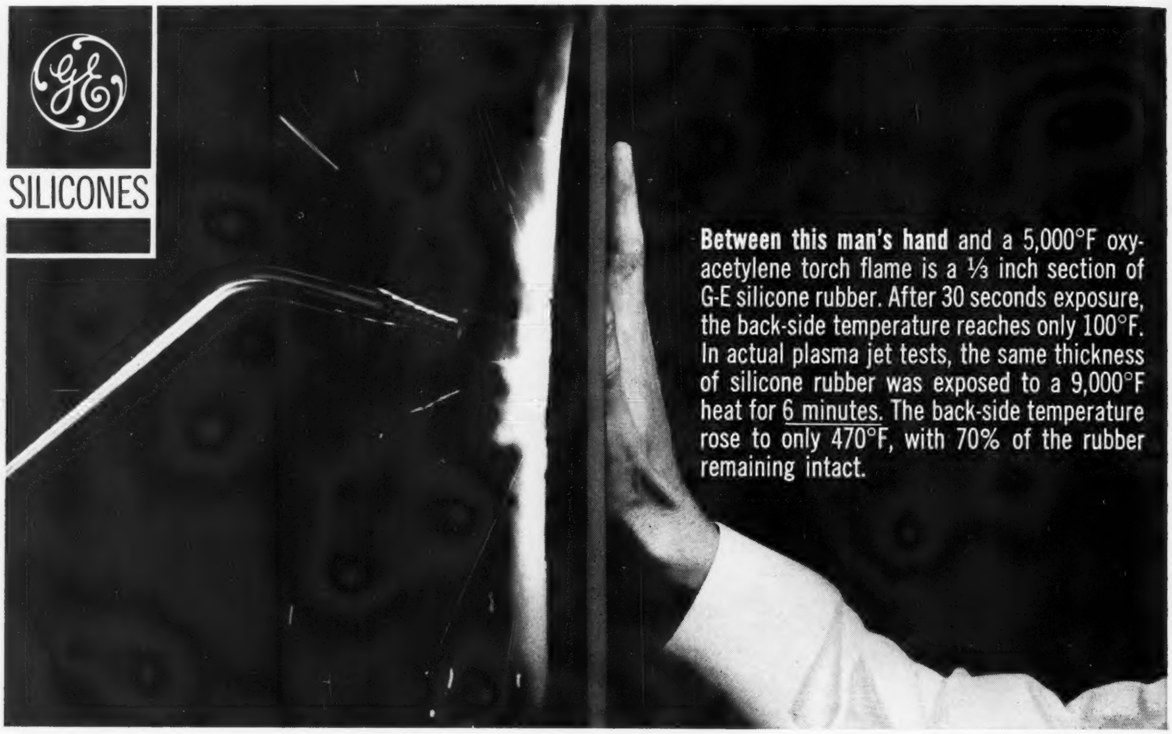
TIMET®

TITANIUM METALS CORPORATION OF AMERICA

233 Broadway, New York 7, N.Y.

SALES OFFICES: NEW YORK
CLEVELAND • CHICAGO • DALLAS • LOS ANGELES

Key number 11



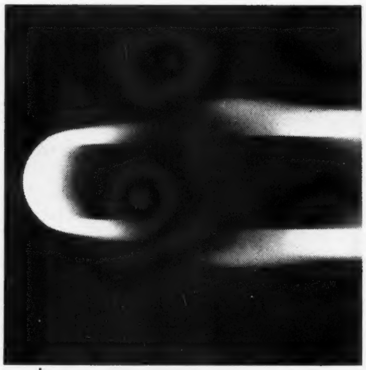
Thermal barrier against 5000°F flame

GENERAL ELECTRIC SILICONE RUBBER

RESULTS OF PLASMA JET TESTS AT 9,000°F

Flight Simulation
Vel. = 17,000 ft./sec.
Alt. = 250,000 ft.

Exposure time at 9,000°F	Back-side temperature of ⅓ inch section of G-E silicone rubber
30 seconds	100°F
2 minutes	210°F
3 minutes	300°F
4 minutes	375°F
5 minutes	430°F
6 minutes	470°F



The surface of the tested rubber section forms a hard, carbonaceous crust, while the underside remains flexible and undamaged. Preliminary tests showed the effective heat of ablation to be eight times better than presently used plastics, with one-seventh the rate of ablation and one-fourth the weight loss. Here is an excellent ablative covering with low thermal conductivity.

The above chart shows how the high thermal insulation of G-E silicone rubber is maintained during exposure to 9,000°F heat. It is also useful in mechanical and electrical applications at temperatures from —150°F to 600°F, where it remains resilient and flexible. It also maintains its excellent physical and electrical properties over this wide temperature range for extended periods.

Continued high temperature testing goes on at General Electric's Missile and Space Vehicle Department in Philadelphia. Shown above is a typical specimen undergoing plasma jet testing in an electric arc heated supersonic wind tunnel. Continuous testing like this will develop new data on the thermal and ablative uses of G-E silicone rubber.

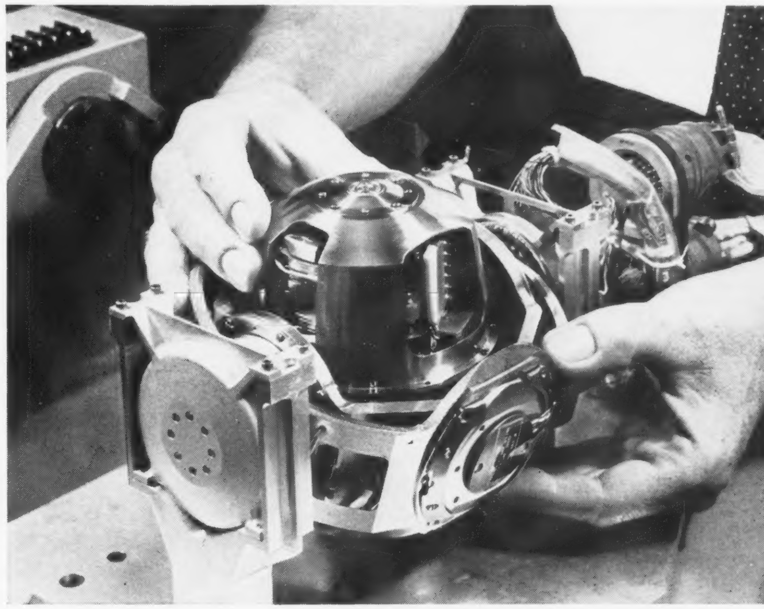
To learn more about G-E silicone rubber, and its uses as a thermal and ablative material, write: General Electric Company, Silicone Products Dept., Section V1061, Waterford, New York.

GENERAL ELECTRIC

Key number 12

FROM SMALL TO SMALLER IN INERTIAL PLATFORMS

Litton P-300 containing two new gyros, three improved accelerometers, four gimbals, and an advanced, irrotational vibration mount compacted into a 0.245-cubic foot, 15-pound unit for missile and space applications.



The Litton P-300, a miniaturized inertial reference platform that rests comfortably in one's two hands, is the result of a program aimed at developing a small, light, reliable unit for orbital and suborbital vehicles. The challenge presented by the P-300 project at its outset was the formidable one of taking an already small production platform (the 30-pound Litton P-200) and chopping it in half without sacrificing performance.

As in the P-200, floated, two-degree-of-freedom gyros were selected to minimize the number of gyro rotor assemblies and to simplify the stabilization servo loops. The gyros were made smaller and their performance increased through the reduction of minor error torques, such as those from flex leads making electrical interconnection between float and case. The gyro wheel, float, and gimbal were constructed primarily of beryllium, greatly improving the stiffness-to-density ratio and reducing the mass shifts caused by aniso-elasticity under acceleration. Despite the smaller size of the gyro rotor, high angular momentum was obtained by distributing the rotor mass in a manner that provides a large radius of gyration.

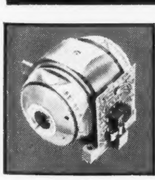
Gas-lubricated bearings are another and particularly noteworthy improvement in the small (2.1″ by 2.9″), light (under 2 pounds) gyros. These bearings use 1/20th of the clearance between bearing surfaces normally associated with oil-lubricated assemblies and offer other advantages that improve gyro performance by an order of magnitude.

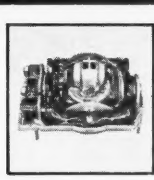
The accelerometers in the P-300 were scaled down (to 0.8″ x 0.8″ x 1.5″) through similar imaginative engineering techniques without decreasing performance. Small and greatly improved, these accelerometers contain a sensitive element that is a floated pendulum mounted on a pair of jewel-and-pivot bearings and equipped with an electromagnetic pickoff and torquer. The relative motion of the pendulum is kept to a small fraction of a milliradian even at an acceleration of over 20 g.

Another feature of the P-300 is the use of direct drive gimbal torquing. By incorporating this type of torquing, the weight penalty paid in motors and gear trains has been greatly reduced. In addition, direct torquing significantly increases accuracy of the attitude readout.

The P-300 inertial platform is the latest of more than half a dozen inertial navigation systems that have been successfully developed to the operational phase at Litton Systems. The Litton engineers who researched and developed these systems are always pleased to divulge additional details. Equally important, they are anxious to exchange ideas with new associates who have a sound flair for engineering of this sort. Write, phone or drop by for a visit. Mr. Don Krause, Litton Systems, Inc., Guidance & Control Systems Division, 5500 Canoga Avenue, Woodland Hills, California. Telephone DIamond 6-4040.

An Equal Opportunity Employer



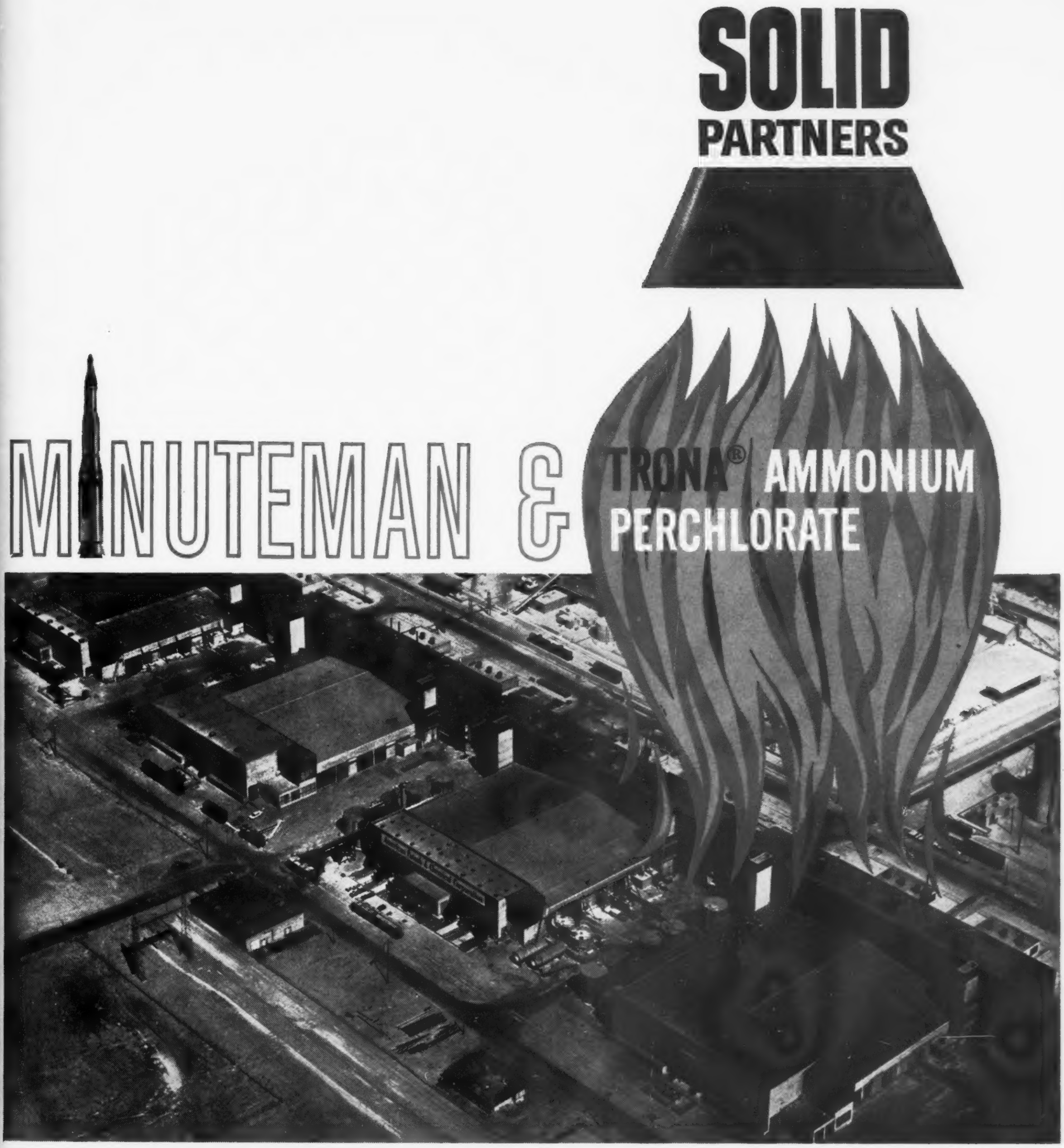


LITTON SYSTEMS, INC.

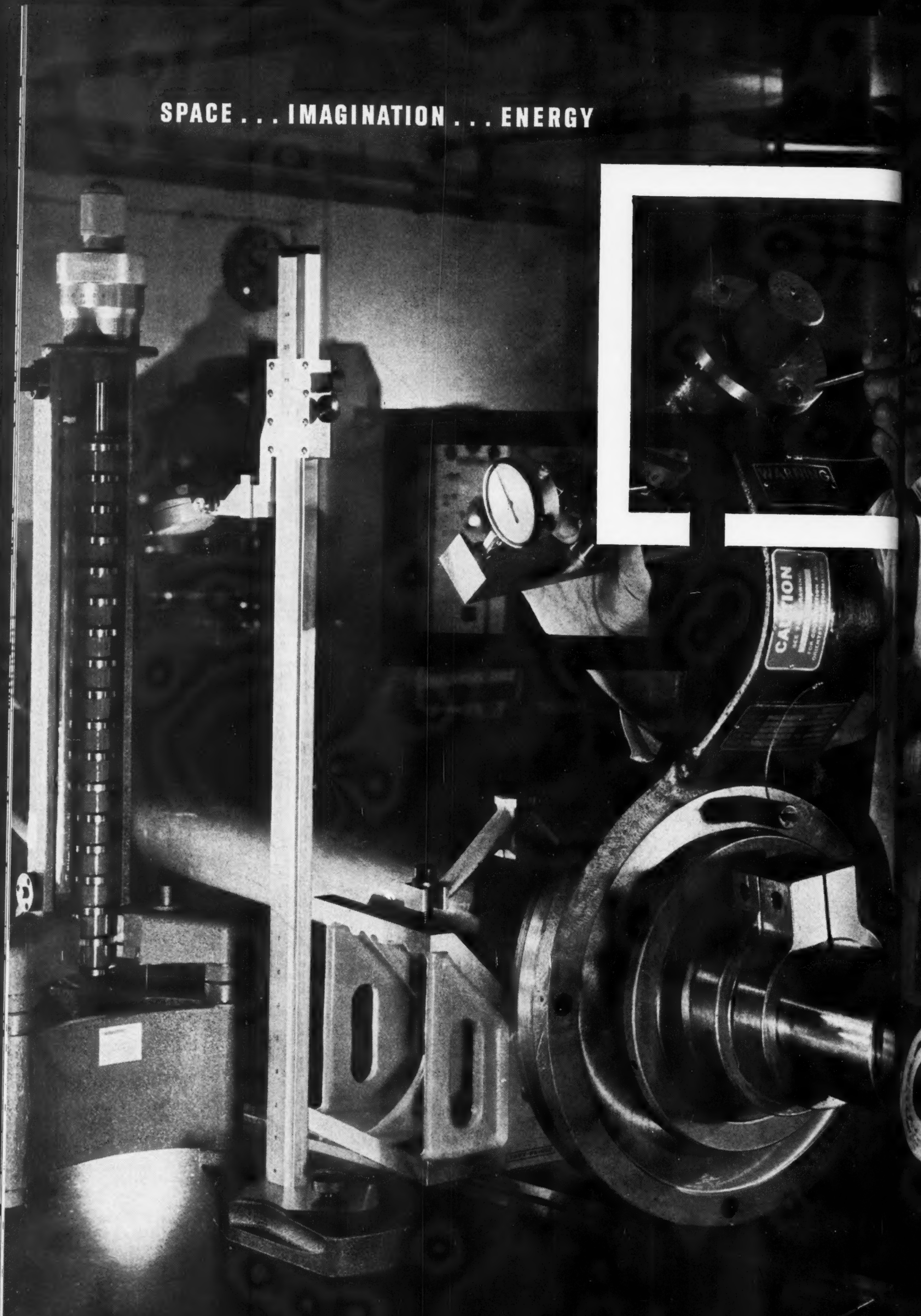
A DIVISION OF LITTON INDUSTRIES

GUIDANCE & CONTROL SYSTEMS • COMPUTER SYSTEMS • DATA HANDLING & DISPLAY SYSTEMS • SPACE SCIENCE • BIOELECTRONICS • ADVANCED COMMUNICATIONS TECHNOLOGY

Key number 13


SOLID
PARTNERS
MINUTEMAN &
TRONA® AMMONIUM
PERCHLORATE

SPACE . . . IMAGINATION . . . ENERGY



Millionth-Inch Accuracies For Million-Mile Journeys

The Primary Standards Laboratory at Hercules' Bacchus plant has a fundamental accuracy of four one-millionths of an inch. This is second order only to the National Bureau of Standards in Washington. Here is the calibration point for all measuring, gaging, machining, and assembly of the third-stage motor for Minuteman, the advanced second-stage motor for Polaris, and in development of the ultraprecision retrorocket for Ranger.

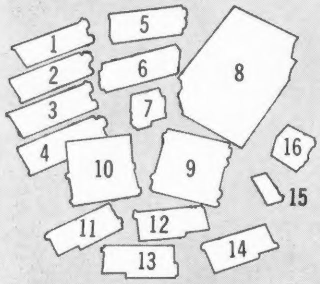
There is good reason for such stringent physical accuracy. Missiles or space vehicles—whether they are to travel hundreds or thousands of miles, or into far distance—must traject with pin-point precision. And, unless the final stage is manned, or under cybernetic control, the governors of its final course are purely ballistic: the force, time, and direction with which its motor was originally endowed.

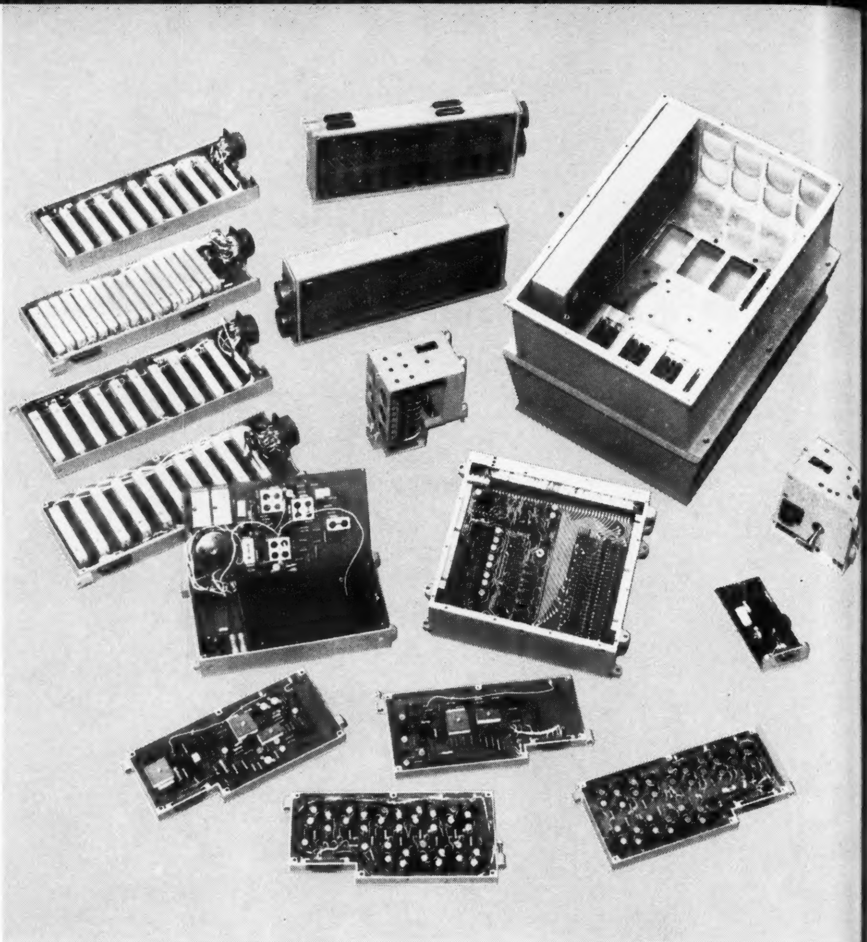
The factors of force and time are subject to chemical prediction; precision and dependability in this area are the backbone of Hercules' current contributions to missilry. Direction of application, however, is a purely physical thing, and calls for new orders of accuracy in manufacture. It is for this reason that the Primary Standards Laboratory at Bacchus is one of the key units of the Chemical Propulsion Division.

Chemical Propulsion Division
HERCULES POWDER COMPANY
INCORPORATED
Hercules Tower—910 Market St., Wilmington 99, Del.

XP61-3

1-6 Commutator assembly—analog input
7 Digital input processor
8 Housing
9 Programmer
10 Low-level amplifier and super multiplexers
11-13 Analog to digital converter
14 Automatic, drift and gain compensation networks
15 Output filter
16 Power converter





NOW PCM TELEMETRY SYSTEMS
...for millivolt data inputs!

Now on short delivery schedules . . . Texas Instruments offers high accuracy pulse code modulation telemetry systems for millivolt, high level or combination inputs.

The complete PCM system shown is a lightweight, 0.9 cubic foot package that multiplexes and encodes 196 analog channels to eight-bit accuracy and processes six digital data inputs. Output information rate is 173,000 bits per second. The system's unique zero and full scale digital servo loop corrects system drift and gain change to assure overall system accuracy of $\pm 0.4\%$ in missile environments. Precision low-level electronic commutation is accomplished with less than ± 20 microvolt off error over a 0 to 70°C temperature range.

PCM encoding and decoding is only one of seve advanced data link projects at TI. Others inclu millivolt oscillators, signal conditioners, solid-state tra mitters, FM/FM systems, advanced microwave co ponents, programmers, command and control syste and space electronics. For detailed information on T capability to meet your particular requirements, conta MARKETING DEPARTMENT.

APPARATUS DIVISION
PLANTS IN DALLAS
AND HOUSTON, TEXAS

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE
P. O. BOX 6015 DALLAS 22, TEXAS

Key number 19

SCIENTISTS — ENGINEERS ATTENDING THE AMERICAN ROCKET SOCIETY MEETING

For the record

The month's news in review

Aug. 3—Discoverer XXVIII fails to orbit.

Aug. *6*—Soviet Cosmonaut Gherman Titov rides into orbit aboard Vostok II.

Aug. 7—Cosmonaut Titov circles earth 17 times in Vostok II, stays aloft 25 hr and 18 min, travels more than 435,000 mi., and makes a successful landing on earth.

Aug. *8*—Atlas-F is successfully fired 5000 mi. into Atlantic Ocean at speed reaching 15,000 mph.

Aug. 10—X-15 with 57,000-lb-thrust engine is flight-tested by Navy Comdr. Forrest S. Petersen; cockpit pressure system fails.

Aug. 12—Polaris-firing sub, Abraham Lincoln, launches a record *six* missiles underwater in one day.

Aug. 15—Explorer XII, first in a series of four tests by NASA to study the behavior of electrons and protons and the two Van Allen Radiation Belts, is launched into orbit.

Aug. 16—F-1 developmental engine fails, owing to a broken switch, after $1^1/_2$ sec during first firing of a complete system.

Aug. 17—AF fires Blue Scout rocket to 140,000-mi. altitude, but loses radio contact with payload at fourth-stage burnout.

Aug. 22—Nationalist China announces plans to open an extensive rocket-research program.

Aug. 23—Ranger 1A is placed in parking orbit—apogee, 312 mi., perigee, 105 mi.—instead of planned 685,000-mi. apogee and 37,500-mi. perigee; Agena stage fails to fire.

Aug. 24—NASA announces that Cape Canaveral will be enlarged to more than five times its present size to handle Apollo and Nova programs.

—International Astronomical Union goes on record in opposition to Project West Ford until question of permanence of hairlike copper needles is settled.

Aug. 25—Explorer XIII, a dust-detecting satellite, is launched into orbit.

Aug. 26—Aerojet-General segmented solid rocket develops half-million pounds thrust.

Aug. 28—AF cancels plans to orbit a monkey in a Discoverer satellite.

Aug. 29—NASA increases number of Ranger launchings from five to nine.

—Explorer XIII re-enters the atmosphere.

Aug. 30—AF launches Discoverer XXIX into polar orbit.

—Minuteman blows up in silo during first underground-launching test. ♦♦

CREATIVE ELECTRONICS BY RCA

NORAD ON THE ALERT

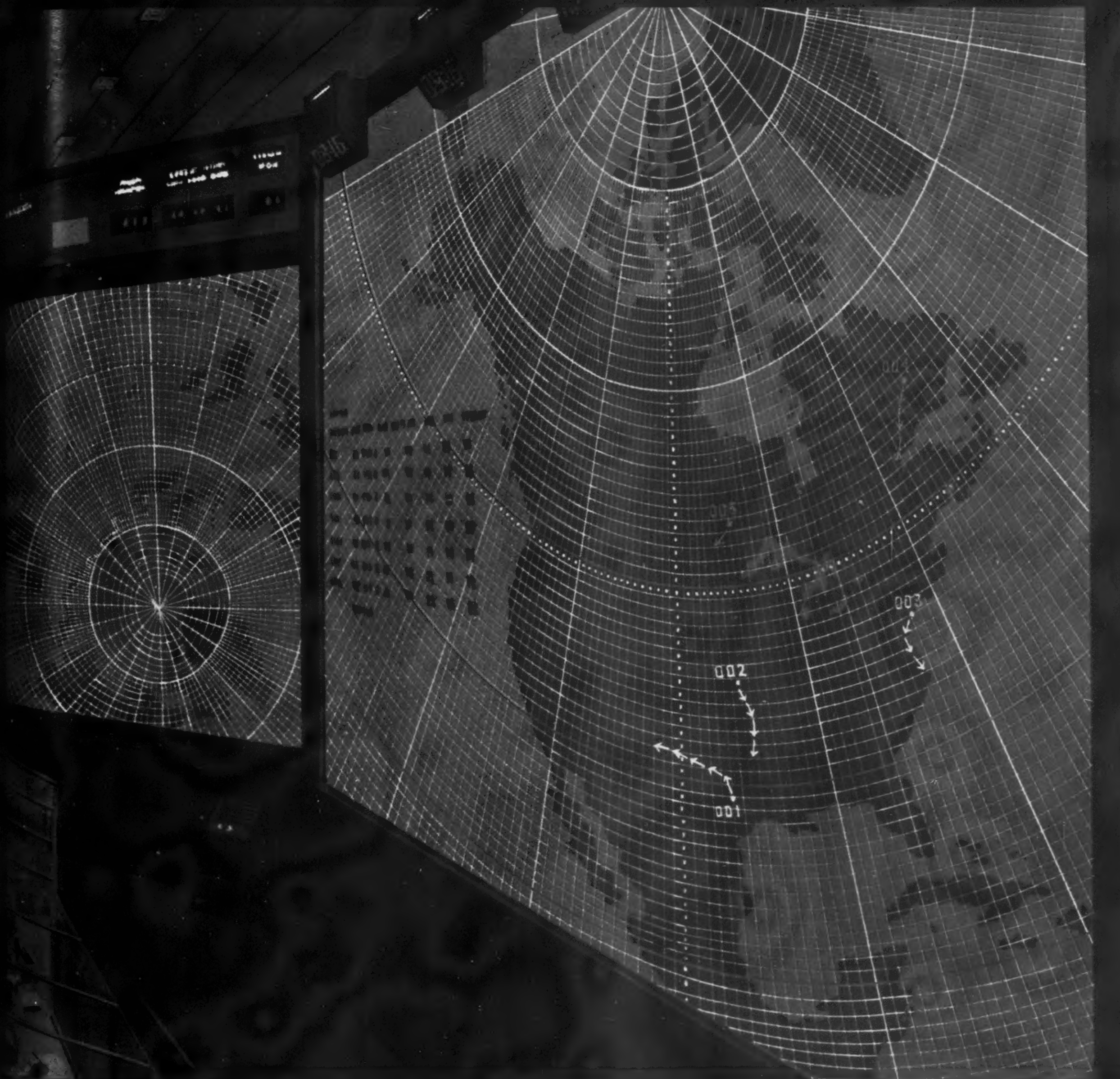
Inputs from BMEWS Provide Instantaneous Missile Data Direct to NORAD Headquarte

From our vast outer defense perimeter, over thousands of miles, to the nerve center of the North American Air Defense Command at Colorado Springs, the most advanced concept of data handling and checkout is being utilized in the BMEWS system. The stakes are high, for the purpose is defense of the North American Continent.

At BMEWS installations operated by USAF Air Defense Command, computers read out missile tracking data from giant radars. This information is simultaneously relayed to NORAD's Combat Operations Center.

The Radio Corporation of America is prime systems contractor for BMEWS. At the COC, RCA's Display Informati Processor computing equipment automatically evaluates missi sightings, launch sites and target areas. By means of data pro essing and projection equipment installed by RCA and a team other electronics manufacturers, the findings are displayed huge, two-story high map-screens in coded color symbols, pr viding the NORAD battle staff with an electronic panoram of the North American and Eurasian land masses.

The handling of BMEWS inputs at NORAD is an example how RCA data processing capabilities are assuring the high d gree of reliability so vital to continental defense.



NORAD Headquarters, RCA computing equipment, the Display Information Processor (control console shown here) receives sightings data from BMEWS and processes it for automatic readout.

RCA is prime system contractor for the sprawling BMEWS three-site radar network whose probing electronic fingers reach deep into space to provide early warning of missile attacks.

RCA's Automatic Checkout & Monitoring equipment continuously tests and checks performance of portions of the system and alerts an operator when a monitored signal exceeds certain limits.

...t of the defense needs of today a new generation of RCA electronic data processing equipments has been born. For tomorrow's needs RCA offers one of the nation's foremost capabilities in research, design, development and production of data processing equipment for space and missile projects. For information on these and other new RCA scientific developments, write Dept. 434, **Defense Electronic Products,** Radio Corporation of America, Camden, N. J.

RCA ®

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

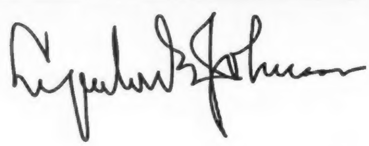
A Message from the President

THE SEARCHING EXAMINATION of United States progress in astronautics provided by the American Rocket Society SPACE FLIGHT REPORT TO THE NATION could not be more appropriate nor more timely. Until now, the opportunity for both the professional engineer and scientist and the public to see and hear the whole story has been lacking. It is therefore heartening to see that ARS has taken the lead, in cooperation with government and military agencies, educational and scientific institutions, and industrial companies, in making available, both to the professional and to the public, full information about the present U.S. space program and, even more important, about this country's future plans for space exploration.

As I noted in my May 25th Special Message to Congress on Urgent National Needs:

> Now it is time to take longer strides—time for a great new American enterprise—time for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on earth . . .
>
> I believe we should go to the moon. But I think every citizen of this country . . . should consider the matter carefully . . . because it is a heavy burden, and there is no sense in agreeing or desiring that the United States take an affirmative position in outer space unless we are prepared to do the work and bear the burdens to make it successful . . .
>
> This decision demands a major national commitment of scientific and technical manpower, material and facilities . . . It means a degree of dedication, organization and discipline which have not always characterized our research and development efforts. It means we cannot afford work stoppages, inflated costs of material or talent, wasteful interagency rivalries, or a high turnover of key personnel.
>
> New objectives and new money cannot solve these problems. They could, in fact, aggravate them further—unless every scientist, every engineer, every technician, contractor and civil servant gives his personal pledge that this nation will move forward, with the full speed of freedom, in the exciting adventure of space.

John F. Kennedy



Space: Catalyst for progress

The expanding space effort has already produced a significant impact around the world, particularly in international relations, with the prestige of a nation now measured by a new yardstick: Its scientific accomplishments and its achievements--or lack thereof--in space

By Vice-President Lyndon B. Johnson

CHAIRMAN, NATIONAL AERONAUTICS AND SPACE COUNCIL

This is the decisive decade in human history. We live in what Toynbee calls a "time of troubles"—awesome troubles perhaps as dangerous to the continuance of the race as the last ice age. Certainly this is the most perilous period civilization has faced since the fall of Rome, but it is also the most exciting and promising. Men are burrowing into our planet's crust to save themselves and their families in the event of nuclear holocaust. Yet at the same time their eyes are on the stars. Should war come, the survivors may be hurled back into the Dark Ages. However, if by a combination of steadfastness, strength, and imagination we hold the peace, the possibilities for thrilling advances by mankind are limitless as the universe itself. For our "time of troubles" is also the dawn of a new age of exploration—the exploration of outer space.

The expanding space effort has already produced significant impact around the world, particularly in international relations, the emphasis on scientific education, meteorology, astrophysics, and medicine. Space advances will affect the thinking and behavior of mankind at a geometrically increasing rate.

Outer space is essentially a limitless and shareable resource of all humanity, and I suggest that this be the basis for a legal space code which must become a part of international law to insure peaceful and efficient exploration and use. Such a code is already under study in this and other countries and in the United Nations. Russian and American satellites have circled the earth unmolested, and it is my opinion that this has already formed a precedent akin to the established law of freedom of the high seas. Every nation has exclusive sovereignty over its air space, but does not possess sovereignty in the area in which satellites orbit. I suggest that the orbital zone be the demarcation line—what on the seas would be the "three-mile limit"—defining the boundaries of outer space.

We must also have agreements covering the return of spacecraft to their owners should they come down on foreign soil. We must have covenants covering space broadcasts, wavelengths, and the triggering of transmissions. We should have agree-

ments covering responsibility for damage or loss of life in the event that a space vehicle gets out of control and impacts in another country.

A nation's prestige is now measured by a new yardstick—its achievements, or lack thereof, in space.

It is not enough to sit down at the international conference table backed by armed might and industrial maturity and material wealth. Scientific accomplishments, especially those in space, are also of major importance.

This we learned, the hard way, when in 1957 the Russians orbited Sputnik I. That little beeping ball became a symbol of Soviet power. And as larger and larger spacecraft were orbited and the Russians also impacted, circled, and photographed the moon, Soviet prestige soared in proportion.

I think it fair to say that there is not now a measurable over-all "gap" between the American and Russian space effort. In some respects the U.S. is ahead; in others, the USSR. In brute rocket power, the Russians lead. In instrument sophistication, scientific evaluation of the new environment, and in number of successful launches, we lead. At this writing 49 American satellites have been placed in earth orbit compared to 13 Russian satellites. Many of our satellites are collecting, and relaying to earth, important data of benefit to all humanity. We do not conceal this information.

Our policy of making our shots in the open so that failures as well as successes are exposed to public view has proved an important asset for us. We need bigger boosters and we are working to get them. The Russians need freedom, particularly a free and uncensored press. Are they working for that? The fact that no (CONTINUED ON PAGE 196)

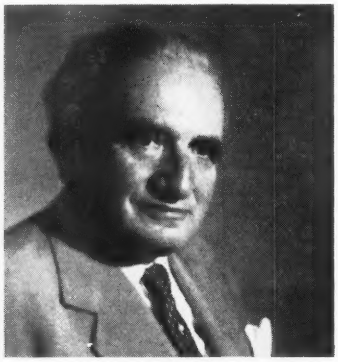
"It is no longer enough to sit down at the international conference table backed by armed might and industrial maturity and material wealth. Scientific accomplishments, especially those in space, are also of major importance."

Space-age education

While, on the one hand, the continuity of the engineering profession and engineering education can be preserved, on the other, an honest effort is necessary to adapt our educational system to this new age

By Theodore von Kármán

ADVISORY GROUP FOR AERONAUTICAL RESEARCH AND DEVELOPMENT, NATO, PARIS



Theodore von Kármán is so well known to anyone active in the space-aeronautical field as to make any biography superfluous. An inspiration to two generations of aeronautical and astronautical engineers and scientists, he is today, still hale and hearty at 80, chairman of AGARD-NATO; chief consultant and chairman of the technical advisory board of Aerojet; scientific director and honorary chairman of the Board of General Applied Science Laboratories; chairman of the board of direction of the Training Center for Experimental Aerodynamics at Rhode-Saint-Genese, Belgium; director of the International Academy of Astronautics; and editor-in-chief of *Astronautica Acta*. Dr. von Kármán became the first ARS Fellow Member in 1949, and a full listing of his honorary degrees, decorations and orders, and awards, as well as his accomplishments, would take up a goodly portion of these pages.

CHANGES IN OUR educational system have always followed, with variable delays—due primarily to the degree of resistance to new ideas—the essential changes in scientific knowledge and progress in technology. Thus it appears natural that our recent interest in the space sciences and space technology should produce certain changes in the programs of our educational institutions at all levels. And, since the attention of our whole nation—and, of course, many other nations—has been directed with rare intensity and practically without resistance in this new direction, we may assume that such changes will come about very shortly.

The most obvious point in a revision of our educational programs due to the "space-age" viewpoint is an increased interest in astronomy and celestial mechanics. Without a doubt, astronomy was one of the first sciences of man in ancient civilizations. Indeed, "a practical acquaintance with the elements of astronomy is indispensable to the conduct of human life." Hence, it is widely diffused—we quote from the article of the *Encyclopedia Britannica* on the history of astronomy—among uncivilized peoples whose existence depends upon immediate and unvarying submission to the dictates of external nature. In China, Egypt, and Babylonia, for example, strength and continuity were lent to this native tendency by the influence of a centralized authority, and considerable proficiency was attained in the arts of observation.

Such observation we find systematized especially in three ancient civilizations: In China, beginning in the third millenium B.C., in Egypt, and in Babylon. In China, I had an interesting personal experience. I visited it about 35 years ago, when the government, whose seat was in Nanking, asked me to advise them in the planning of a kind of national research center to consist of several research institutes for the various sciences. As we started the discussion, the Chinese representative came forth with the definite proposal that the first institute must be that devoted to astronomy. When I objected that maybe some other branch of science which would have more direct influence on China's technical progress would be preferable as a first effort, the Chinese gentleman answered that, according to Chinese tradition of many thousands of years, astronomy was considered the "noblest of sciences" and it was imperative that the present effort should start with a modern astronomical observatory. Due to the change of government, nothing resulted from our planning, but this discussion became unforgettable to me.

Astronomy as a science was consolidated by the Greeks, and especially by the School of Ptolemy of Alexandria, in the direction of mathematical formulations. During the Roman era, the Middle Ages and in the Age of Copernicus, Kepler, and Galilei, astronomy was often in the center of interest beyond strictly scientific circles because of conflicts with religious and other generally adopted opinions on the structure and laws of the universe.

Later, astronomical science became more or less a specialized domain, involving mathematical knowledge or a knowledge of special methods of optical and, lately, of radar observations. It would be interesting to find out whether the number of amateur owners of telescopes in the United States from the time of Benjamin Franklin and Thomas Jefferson has increased proportionally with the population.

In the field of general education, I believe it is justified to state that our schools give only the most primary elements of descriptive astronomy. I do not know whether my observation is correct, but I find, comparing the education of my own generation in Europe 70 years ago with the education of our youngsters in the American high schools, that we were much more interested in things like the sky than the present youth, who have a special interest in mechanical devices. I remember that I had at home a sky-map which could be adjusted to the day of the year and the hour of the day; and, if the sky was clear, we played around with the map, especially at vacation time, trying to identify the stars and the constellations, separating the planets from fixed stars, and so on.

Now, I believe that the present interest in the space age will also increase the interest of our youth in the sky in general, and I believe that elementary and high schools should revise their programs and give more descriptive astronomy and celestial dynamics.

The readers of this journal devoted to an important branch of engineering may be interested in how the space age should influence engineering education.

First we may ask: What is the definition of "engineering education?" I read once that it is transferring the experience of one generation to the next. I don't think this really covers the whole meaning of engineering education; it was recognized very early that the transmission of experience is not sufficient.

A Perspective for Empirical Data

The great British engineer Rankine said: "A practical engineer is a man who perpetuates the mistakes of his predecessors!" I don't want to say anything against the practical engineer, but Rankine was among the first who thought that the transmission of empirical data—the transmission of empirical knowledge—is not sufficient.

You cannot say anything against empirical data. I understand, for example, that hydraulics, which I once, somewhat irreverently, called "the science of variable constants," could not start with the real theory of hydrodynamics.

Even now, we are not so far along that we understand all the phenomena of turbulent motion. And, after all, river flows and most motions in pipes and channels are turbulent motions.

So empirical data and empirical rules are very important. However, we must know exactly for which cases we want empirical data, and in which domains they can be employed.

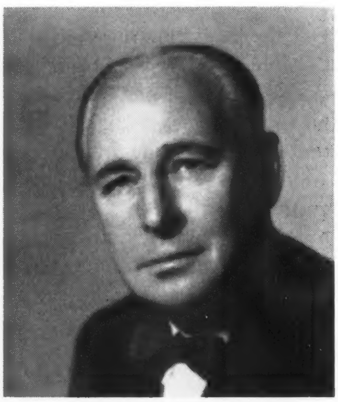
Some people say an engineer is a scientist. I don't think this is quite correct. Engineering education is not only to educate scientists. After all, the engineer is a man who creates—not only ideas, not only theories, but also (CONTINUED ON PAGE 126)

Space flight and science

When we land on the planets to examine the life there, we will achieve perhaps the most treasured scientific opportunity of all time, and yet this is only one of the many scientific payoffs of space exploration

By Lloyd V. Berkner

SPACE SCIENCE BOARD
NATIONAL ACADEMY OF SCIENCES, WASHINGTON, D.C.



Lloyd V. Berkner is president of the Graduate Research Center of the Southwest, chairman of the NAS's Space Science Board. Dr. Berkner's broad interests and achievements as a scientist and administrator also bring him this year to the presidency of the IRE and the American Geophysical Union. Trained as an electrical engineer and physicist, and qualified as a Naval aviator in 1926, Dr. Berkner was selected as engineer to the First Byrd Antarctic Expedition in 1928–30. During the 1930's, he began a long association with the Carnegie Institution and, working as a geophysicist, went to Australia and Alaska before the outbreak of WW II. The war years saw him head first the BuAer Radar Section and then its Electronics Material Branch. Since WW II, Dr. Berkner has held numerous directing and consulting positions with the government, international bodies, private institutions, and industry—among them executive secretary of the DOD Research and Development Board (1946–47), president of the International Council of Scientific Unions (1955–58), IGY vice-president (1953–59), and member of the board of directors of Texas Instruments, Inc. (1958–). Dr. Berkner's honors include, among many others, a Congressional Gold Medal for his contributions to the Byrd Expedition, the U.S. Legion of Merit, and honorary degrees from universities here and abroad.

When President Kennedy announced the determination of the United States to undertake exploration of the moon and planets, he committed our nation to perhaps the most extraordinary goal to which man has aspired in his entire history. Throughout his rise to civilization, man's speculation about the heavenly bodies around him has occupied a central place in his mythology and in his philosophy. As science came into being, man acquired the physical tools—quadrants, astrolabes, telescopes, spectroscopes, cameras—that brought him closer to the realities of the heavens, and the relationships among the celestial bodies.

Yet throughout his history the idea that he might one day travel to the moon and the planets to examine them at first hand has seemed inconceivably beyond his reach. After millenia of hopeless aspiration, the reality of the seemingly preposterous ambition to journey within the solar system appeared to be close at hand when our nation formally declared that exploration of the nearby heavenly bodies was within our technical and economic capability. Certainly 1961, this year of great space decision, will be marked very clearly as a milestone in the history of civilization's advance.

The very aspiration toward lunar and planetary exploration implies immediately a scientific exploration. Certainly, the ability to land a vehicle on the moon and to return it is in itself a mark of great technological dexterity. Certainly the human adventure and inspiration represented by manned travel to nearby celestial objects transcend any previous technical accomplishment in man's courageous history. Beyond these transient goals, however, lies the fundamental aspiration of knowing what is there, of satisfying man's curiosity to understand the nature of things. This basic motivation—to comprehend—is the goal of all of science; it is at the root of our ambition to reach the moon and the planets.

Since the ultimate goal of space exploration is broad scientific knowledge, we must inquire in more detail of the nature and feasibility of the scientific objectives, and of the ultimate meaning of such scientific truth to man's welfare. Here we encounter some debate. The cost of the proposed lunar expeditions and the preliminary work on planetary exploration is variously estimated at \$20–\$40 billion. So, say some, would not man benefit more if these amounts were spent to bolster scientific endeavor on earth? Would it not be better to finance scientific projects on such things as cancer and heart disease rather than to pour \$20–\$40 billion into reaching

the moon?

In examining this matter, I am going to admit bias at the outset.

Since my first active participation in this space program, I have come to believe more and more firmly that this endeavor is worth the cost and effort to be paid. Indeed, it was back in 1952 that I became firmly convinced that man had reached the stage of science and technology when the return to mankind from a space effort would exceed his investment. Therefore, if I present a seemingly colored view, it is influenced by an intimate association with the scientific and technological aspects of aeronautics for 35 years and of astronautics since about 1943, when we made our first really serious satellite calculations in the Department of the Navy. There are doubtless some scientists in the U.S. who will not agree with my conclusions, but I respectfully submit these are very often men who have not probed very intimately into the potentialities of space science and therefore who do not evaluate the opportunities in the same way. If you wish to study the other side of the case, I recommend to you the article by Mr. Harrington in the May *Reader's Digest* which gives a rather complete outline of what I would call the anti-space attitude.

Now, just to convince you that not all distinguished scientists are opposed to landing men on the moon, I would quote from a document which was adopted by the Space Science Board of the National Academy of Sciences on Feb. 10, 1961, as a recommendation to NASA. The members of the Space Science Board who made this recommendation are Harrison Brown, geophysicist of Cal Tech; Leo Goldberg, the Harvard astronomer; Keffer Hartline, biophysicist of the Rockefeller Institute; Donald Hornig, Princeton chemist; William Kellogg, physicist of the Rand Corp.; Christian Lambertsen of the Univ. of Pennsylvania's Medical School; Joshua Lederberg, Nobel Prize geneticist of Stanford; Colin Pittendrigh, biologist of Princeton; Richard Porter, engineer of General Electric; Bruno Rossi, physicist of MIT; Alan Shapley, ionosphericist of the National Bureau of Standards; John Simpson, physicist of the Institute for Nuclear Studies at the Univ. of Chicago; Harold Urey, Nobel Laureate chemist of the Univ. of California; James Van Allen, physicist of the Univ. of Iowa; Oswald Garrison Villard Jr., engineer of Stanford; Harry Wexler, director of research, U.S. Weather Bureau; and George Woollard, geologist and geophysicist of the Univ. of Wisconsin.

These men joined unan- (CONTINUED ON PAGE 138)

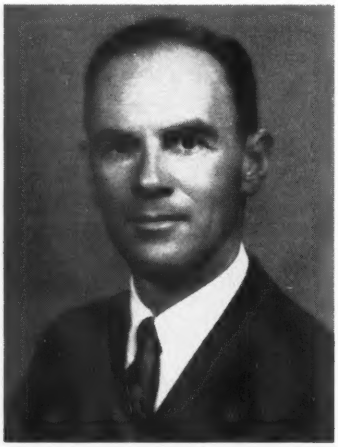
The interplanetary spaceship, depicted here in a NASA Marshall Space Flight Center illustration, will soon be a new home and laboratory for adventurous science.

Military impact of astronautics

While near-term prospects for new space weapon systems do not appear too promising, those already in existence have altered the strategic equation and created unprecedented problems and technical challenges

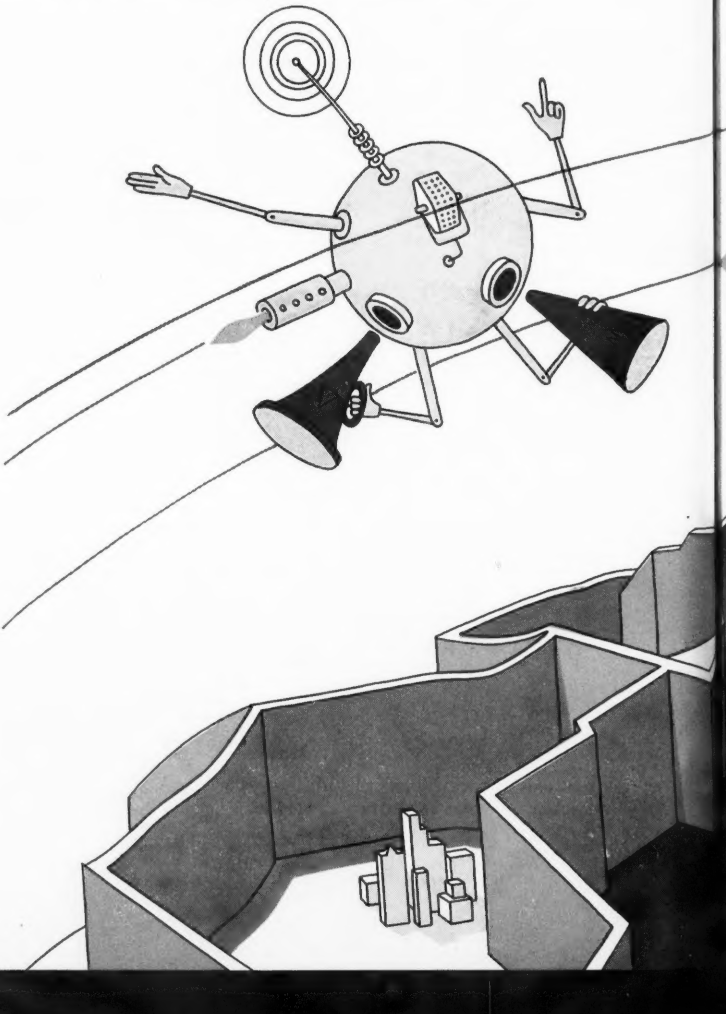
By John H. Rubel

DEPARTMENT OF DEFENSE, WASHINGTON, D.C.



John Rubel has been deputy director of defense research and engineering since April 1960, and was appointed assistant secretary of defense in May of this year. He joined the Defense Dept. in May 1959, as assistant director of defense research and engineering (strategic weapons) after 13 years with Hughes Aircraft Co. While with Hughes, he contributed to the development of one of the earliest successful automatic celestial navigation systems, and also was associated with the development of the Falcon family of missiles. In 1952, he joined the Hughes radar laboratories, later renamed the Airborne Systems Laboratories, becoming director in 1955. It was from this post that he came to the Defense Dept. While with DOD, his responsibilities have included research, engineering, and engineering management aspects of present and contemplated long-range strategic strike forces, as well as operations analysis connected with the design of strategic weapon systems.

"ASTRO" means "of or pertaining to the stars." "Astronautics," taken in its literal sense, relates to the science, to the art, or to the actual operation of "astrocraft." I am sure, however, that a broader interpretation of this term is generally intended, and we will take it here, since even the nearest stars are rather beyond the reach of the practical arts in our time. "Astronautics" will include, for our purposes, the whole of space technology, including orbital and even suborbital missions and capabilities near the earth.



This definition permits us to include the ICBM and IRBM in this consideration of the military impact of astronautics. Some have argued that this is unfair, because it is obvious that these weapons are really no more than long-range artillery, which scarcely ought to be included in the field of astronautics. Nevertheless, as we all know, the ICBM particularly, and even the IRBM, require and apply precisely those elements of structure, propulsion, guidance, control, and the calculation of trajectories which characterize space technology and which will be typical of technical fields and undertakings in astronautics either near or far away from the earth itself.

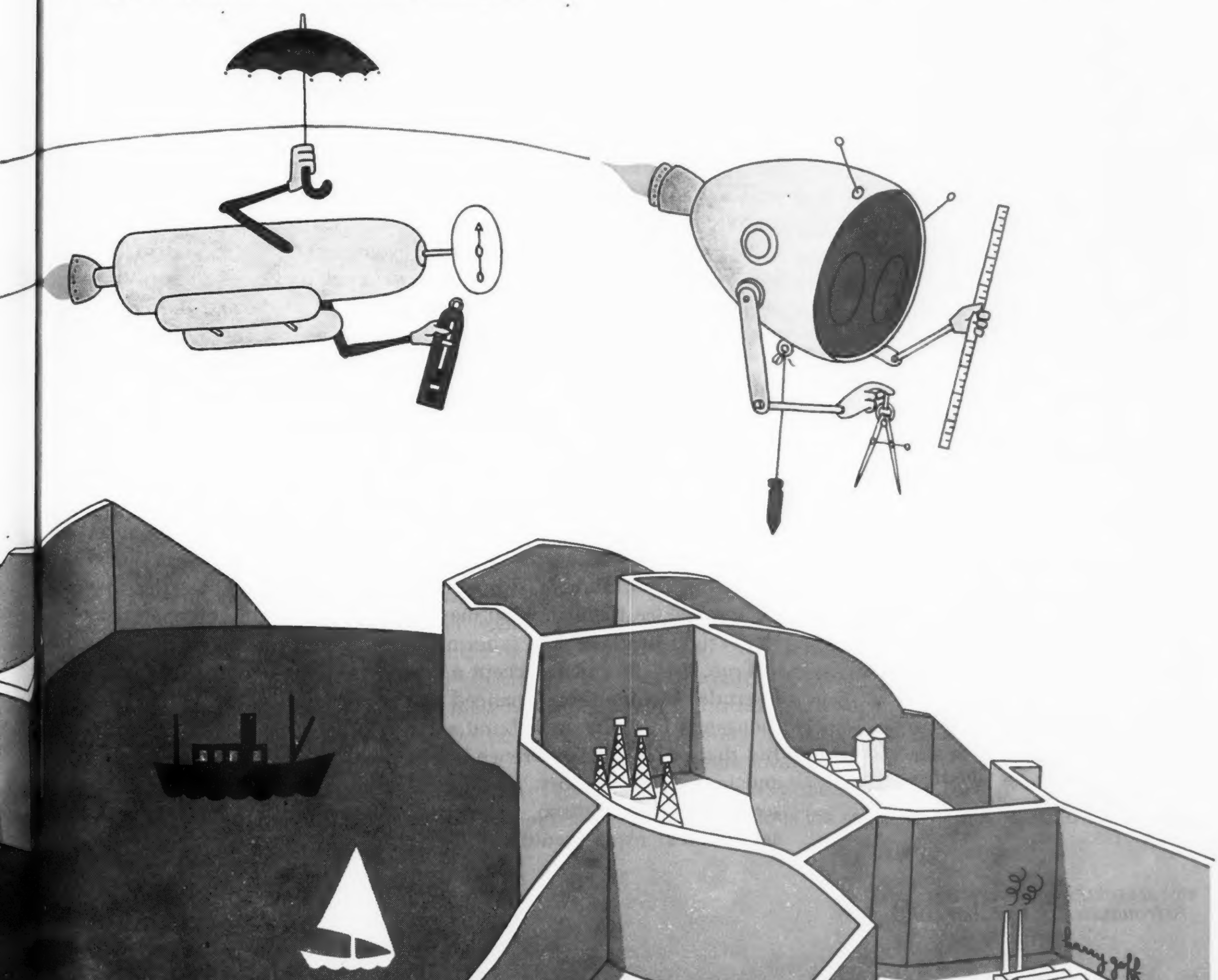
Effects Wide and Permanent

If we accept this definition, including as it does the ICBM and the IRBM, it is clear that astronautics has already had a sizable military impact. It has had a great impact on our military posture. It has had a great impact on the posture of potential enemies. It has had a great impact on our military organizations, our military planning, the level and character of our expenditures, the form of much of our military establishment, to say nothing of our political posture, and the way in which political and military affairs mutually interact.

Moreover, astronautics is a rapidly growing field. It presents many fascinating technical challenges as we seek success on current projects. Each success brings us closer to ever-enlarging capabilities. The growth, the evolution of astronautics creates the certainty that unimagined potentialities are very likely to be brought forth in future years even though they cannot be accurately described at this stage. Thus we are interested not only in the present but in the future. Will it bring world changes such as we have seen in the past few years? What will the military impact of astronautics be 10 or 20 or 50 years from now? Will a space weapon, perhaps not yet conceived, not only obsolete but surpass the ballistic missile in the future?

We look ahead to that future time when our technological capacities will never have been greater, a time at which the Government will be committed to the sponsorship of new (CONTINUED ON PAGE 128)

Communication, meteorological, and geodetic satellites, in the field of what is often called "supporting systems," are of great importance from a military standpoint.



Space-age transportation

Besides traveling throughout the solar system, we will take the tools of space flight and develop a terrestrial transportation system that seemingly defies imagination

By Donald W. Douglas Jr.

DOUGLAS AIRCRAFT CO., SANTA MONICA, CALIF.

Donald W. Douglas Jr., president of Douglas Aircraft since October 1957, joined the company in 1939, after completing engineering studies at both Stanford Univ. and Curtiss-Wright Technical Institute. In his early years with the company, he worked on the DC-3, DC-4, and C-74 Globemaster aircraft, and during WW II he was director of the company's testing division and supervised flight tests of the SBD Dauntless, A-20 Havoc, TB-2D, C-54 Skymaster, A-26 Invader, C-74, XB-42, XB-43, BT2D, and AD-1 Skyraider. Type certification testing of the postwar DC-4 and DC-6 and DC-7 airliners and qualification testing of the D-558 Skystreak, D-558-2 Skyrocket, and F3D Skyknight also were conducted under his direction. He was elected a vice-president in Jan. 1951 and a director of the company in July 1953.

IT IS OFTEN DIFFICULT for one directly engaged in as revolutionary an endeavor as our present space exploration program to place it in proper perspective or even to appreciate fully its immediate possibilities. We are not impartial observers. The hill of current difficulty obscures the grand landscape beyond. But it is profitable to try the role of a less inhibited viewer and recognize that a hill is not an unscalable cliff.

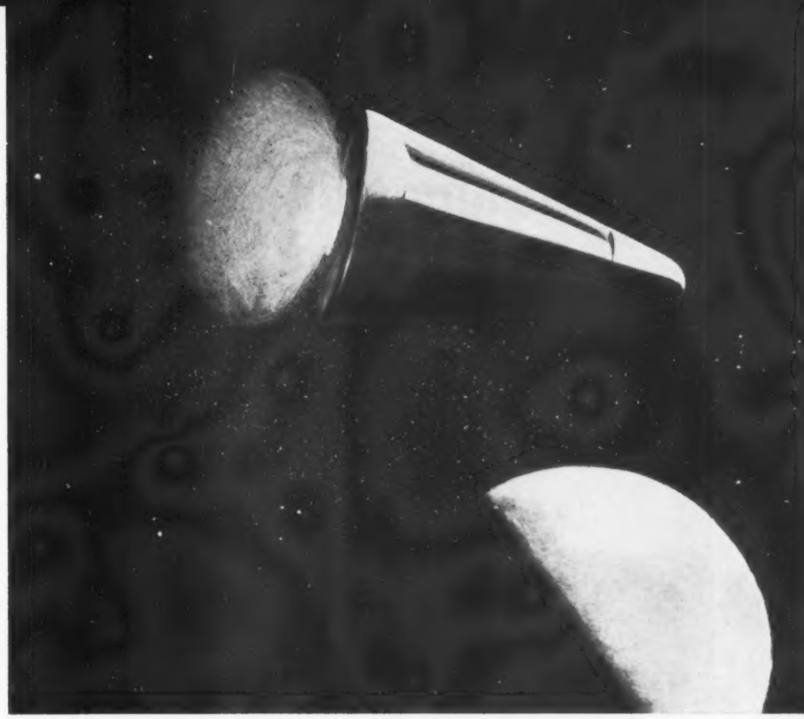
Attempting to draw the implications of our current space projects means predicting the future of a particular branch of technical development. One must try to place events in proper perspective on a time scale. This can best be accomplished by a comparison with a similar past development, rather than by placing sole reliance on synoptic experience. Aircraft development provides an obvious analogy.

It is easy to grossly misplace space flight in such a chronological comparison. Typical erroneous reasoning goes somewhat like this: "The Wright brothers first flew in 1903 and, since Goddard flew his original rockets some 30 years ago and the V-2 development was initiated more than 20 years ago, so, relatively speaking, space flight must be in the 1920's of aircraft development." This comparison neglects the fact that successful *unmanned* powered aircraft date back to the 1870's. Brilliant as Dr. Goddard's works and the Peenemuende developments were, they represent early efforts which may more accurately be compared to those of Alphonse Penaud or Victor Tatin.

The flights of the 1800's were isolated successes, which resulted in relatively brief unmanned flights, and marked the feeble beginning of what later became a nearly worldwide massing of endeavor. To find the space-flight equivalent to the very intensive (for that period) aircraft development efforts being simultaneously carried out in several nations during the 1890's, one must look to the post-World War II period, and more probably to the 1950's. Thus, the first manned space flight in 1960 may be most reasonably compared to the Wright brothers' first faltering flight at Kitty Hawk.

True, it is difficult to accept a comparison of individuals working in crude machine shops financed by private funds with the efforts of thousands in elaborate laboratories financed by community funds. But that is the basic difference between technical development today and in the 19th century. As the laboratory of Franklin must have seemed crude to Edison, so we view the facilities available to early aeronautical experimenters.

Nuclear power and re-usability will be keys to economic space transport, according to Douglas studies. The sketch depicts the company's proposed Rita-B nuclear-powered transport making a course correction on an interplanetary voyage.



Once this chronological comparison is accepted, a view beyond is much clearer. The lunar voyage late in this decade is Bleriot spanning the English Channel; the first manned exploration of near planets is Alcock and Brown landing in Ireland. To engineers of 1903, a crossing of the English Channel was certainly feasible with only a little more engineering development. The non-stop Atlantic flight was possible but, to the rational scientific mind, nearly insurmountable obstacles must have appeared to be in the path. Yet Lindbergh's flight occurred only one and one-half decades later.

Who would have predicted in 1903 the vast utilization of these experiments—the emergence of regular transcontinental commercial flights in less than three decades and of transoceanic service in less than four? ("Surely, it would not be economically feasible and certainly not with land planes.") Who could visualize the modern intercontinental bombardment fleets? ("Surely the enormous cost of development and the complexity of operation would prohibit use of such an invention.") Relating ourselves, with our current inhibitions, to our turn-of-the-century counterparts can be illuminating.

When one predicts mass use of some original experimentation, such as space flight, two questions immediately arise.

Why utilize the development in mass?

Will such extensive use ever be economically feasible?

First, let me reply with a generalization: If vast exploitation of space transportation does not follow, it will be the first time in recorded history such an evolution did not occur. But such a generalization is unsatisfactory; the question is still "why?"

To answer this, let me begin by recalling that there have always been two types of transportation developments: Military and civil. The reasons why it is desirable to utilize this new arena from a military viewpoint are, I believe, obvious and do not need recounting here. Suffice it to say that, as a civilian, I find it somewhat incongruous to restrict military operations to our crowded planet where uncounted numbers of spectators will be slaughtered in the backwash of war while the vast emptiness of space remains uncontaminated.

Engineering Exploitation a Reality

Extensive civil space operations are more difficult to visualize, but even today we are witnessing the beginning of an experimentation followed by a commercial exploitation cycle—namely, the communications satellite. But, the skeptic says, a few containers of electronic paraphernalia whirling a few thousand miles above earth hardly represent massive exploitation of space flight. Yet I wonder if Alexander Graham Bell ever fully realized that an industrial giant such as the modern American Telephone and Telegraph Co. could be founded on communications alone?

In a way the skeptic is correct; commercial communications via space ve- (CONTINUED ON PAGE 132)

Communications for the space age

With the help of equipment in space, the world will be pulled together into a tightly interconnected information dissemination and processing net, ushering in a new epoch in the history of communications science

By Simon Ramo

THOMPSON RAMO WOOLDRIDGE, INC., LOS ANGELES, CALIF.

Simon Ramo, executive vice-president of the Thompson Ramo Wooldridge, Inc., is a senior member of the space-flight community. His leadership in engineering science and management shaped the U.S. ballistic-missile program during its critical period of the early- and mid-1950's, and he has built an outstanding record of contributions to space technology, higher education, industrial planning, and community affairs. Recipient of a B.S. (highest honors, 1933) from the Univ. of Utah and a Ph.D. (magna cum laude, 1936) in physics and electrical engineering from CalTech, Dr. Ramo soon attained prominence for his work on mircrowaves, electron optics, and related topics while with GE's research staff from 1936-46, and during this period accumulated some 25 patents. The year 1946 saw him become director of Guided Missile Research and Development for Hughes Aircraft, and then in 1953, with Dean Wooldridge, he formed Ramo-Wooldridge Corp., which has since merged with Thompson Products. A member of the ARS Board for the past four years, Dr. Ramo has served as a consultant to many groups in the U.S. Government, and is a member of the Air Force Scientific Advisory Board and the Prosthetics Research Board of the NAS National Research Council.

In the coming technological society, communications science and communications facilities will be vastly expanded. The fast-paced, complex physical operations of the world ahead will require great integration because of increased interactions—this despite an enormous increase in the quantity of information to be stored and handled and the rates at which that information will have to be communicated and processed. New technology and innovations in man-machine relationships on the level of intellectual tasks will have to be worked out for message dissemination and categorizing, and for reaching conclusions and implementing decisions based on the changing information, with increasing automaticity as an ingredient. An increasingly intricate web of worldwide communications will be built up to insure order as against chaos in the control of the logistics of our increasingly busy civilization.

Space technology will doubtless be a factor second to none in providing new approaches for solutions to these growing "surface civilization" communications problems. However, in addition, the endless three-dimensional space surrounding the earth becomes itself a new region for which expanded communications techniques and facilities are required. Space research, space travel, and utilization of space for communications equipment to facilitate the solution of earthbound communications problems will open up an expanded area of investigation in the field of communications.

Will Offer Means for Proper Information Exchange

In the future, literally billions of points on the surface of the earth will need to be tied together—man to man, man to machine, and machine to machine as to terminal characteristics—to provide the means for information exchange consistent with the production, transportation, and other operations of the peoples of the earth. Space technology now provides means for placing communication equipment of various kinds in space. Properly exploited, this capability allows us to get around the problem of the earth's being physically between communication terminal points. Space relays offer an economically sound basis for the worldwide communications that are seen for the future. In many important respects, the satellite relay is a better engineering approach than competitive ones of

oceanic cable systems or the bouncing of waves off the ionosphere. However, it should be noted that the communications systems for earth operations, while depending heavily on skyborne apparatus, will nevertheless include even more numerous large complexes of connected, integrated equipment and human participants on the surface of the earth.

With the help of equipment in space, the world will be pulled together, as it must be, into a tightly interconnected information dissemination and processing net. Clearly, national and language barriers will be crossed if a truly efficient and, in fact, a practical system to handle the world's information problems is to exist. Automatic language translation will become a common ingredient of space-age communications. Direct voice-to-voice automatic translation, as well as machine-to-machine information transfer, can be expected. A Russian may speak his native tongue and an English version will automatically appear at the ear of his American conferee at the other end.

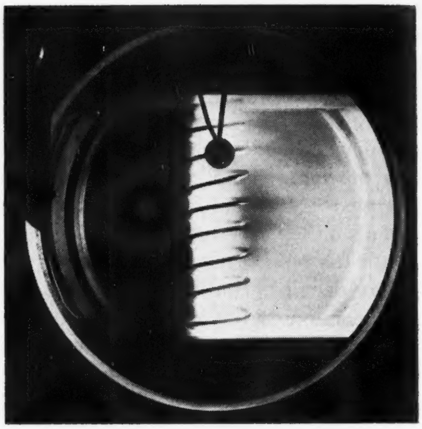
However, the machine partners in the communications system will create pressure for a common, consistent, logical, and informational type of language. This is, in part, because such a language is basically more economical, leads to less errors and confusion, and makes for an all-around sensible technological design. It is also because most of the information that will be sent around the world and out into space will be of a descriptive, often highly quantitative nature, lending itself to logical grammatical construction and an optimally chosen and based vocabulary. As communications requirements increase in the space age and as the increasingly industrialized and populated world comes to depend upon the communications system to assure the flow of decisions, resources, control signals, and supporting services, language reform may influence the whole world.

Taking the lead from the communication system's urging, language modification may become an important unifying communications concept covering speech as well as the transmitted or written communication. The commercial and governmental communication will probably be the first to commence adoption of logical language structures most closely satisfying the requirements of the overall world communications systems, with less urgent communications functions following suit gradually over the decades.

Today's world is already one in which military decisions made by one nation can have in a few moments an impact of consequential nature on another nation on a part of the earth many thousands of miles away. In the future, military defense or world peace, armament, or inspection controls will require communications that match with and belong on this scale of wide geographical spans and short times. It will be necessary to have observation equipment in space capable of observing earth operations continuously, and simultaneously to be able to communicate virtually instantaneously with all parts of the earth's surface and with other points in space. This will, of itself, require an impressive space–earth communications system with its attendant special problems. It will constitute a source of sponsorship in the search to discover new communications techniques and the development of new communications facilities.

Many Fields Involved

Apart from military or peace-control communications problems, the coming world society has other needs for special and large new communication systems. Surface and air navigation and near-in space navigation and traffic control constitute major requirements for advances in communications and information handling, in general. Here, again, equipment in space will be vital to the whole, but much equipment will be needed on the ground. Additional advances will be (CONTINUED ON PAGE 116)



Power in the space age

Plasma research heralds an energy revolution, and promises to channel the advances of space flight into a more abundant life here on earth

By Arthur Kantrowitz

AVCO-EVERETT RESEARCH LABORATORY, EVERETT, MASS.

Arthur Kantrowitz is vice-president and a director of the Avco Corp. and director of its Avco-Everett Research Laboratory. Internationally known for his research in gas dynamics, and particularly for his pioneering application of the shock tube to high-temperature gas problems, Dr. Kantrowitz was previously a professor of aeronautical engineering and engineering physics at Cornell Univ. for a number of years, and also chief of the gas dynamics section of NACA. Dr. Kantrowitz was a Visiting Institute Professor and Fellow at MIT's School of Advanced Study in 1958, and has held Fulbright and Guggenheim fellowships at Cambridge and Manchester universities. A past president of the fluid dynamics division of the American Physical Society, and a Fellow of AAAS, he actively participates in numerous professional and technical societies, and is a member of the engineering sciences division of the International Academy of Astronautics.

SINCE ITS DISCOVERY, nuclear energy has inspired the hope of a coming energy revolution. Following the war-time success with fission reactors, it was hoped that new energy sources would shortly be discovered which would greatly increase the world's productivity. These hopes have not yet come to fruition. However, it is the purpose of this paper to point out the possible relationship between space science and technology on the one hand and progress toward an energy revolution on the other.

In the last few years, there has been a tremendous upsurge of interest in the dynamics of plasmas, sometimes called magnetohydrodynamics (or MHD). A plasma is a gas in which some of the molecules have lost electrons. The presence of free electrons makes the gas a conductor of electricity, and thus it can interact with electromagnetic fields. When it is a sufficiently good conductor, this interaction can balance the pressure exerted by the gas on its surroundings (magnetic containment) and produce forces to accelerate or decelerate the gas.

This interest in plasmas is evidenced by the increasing portion of our scientific meetings and publications which are devoted to the subject. Thus, the American Rocket Society holds several meetings a year devoted to magnetohydrodynamics. The American Physical Society now has three divisions wholly or partially concerning themselves with this area, and several other scientific and engineering societies are also devoting increasing attention to this field. It is clear that in the past few years this has been one of the most rapidly growing research areas in physical science.

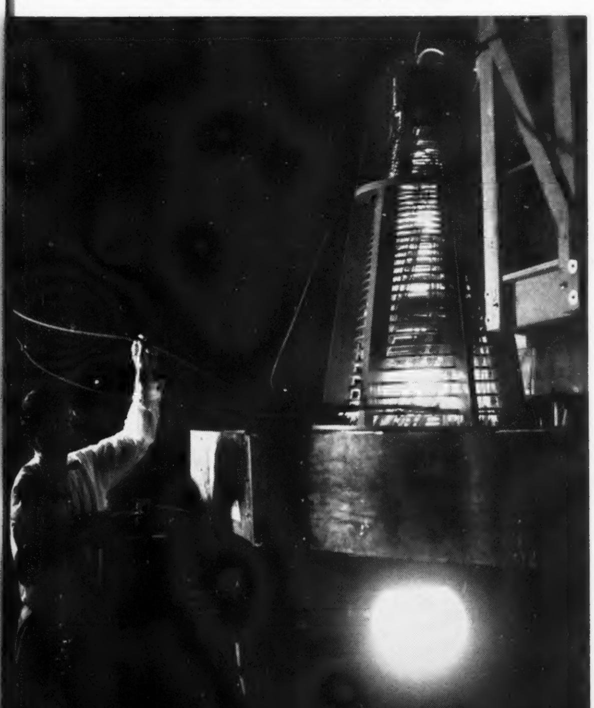
This is actually the second wave of interest in plasmas. The first wave was concerned with the properties of static plasmas. This work had profound effects on science and on technology. Thus, in the first wave the electrons and X-rays were only two of the great

discoveries made. The enormous variety of practical results can be illustrated by mentioning fluorescent lights, thyratrons, and electrochemical processes. The second wave of interest in plasmas and their dynamics is related to two of the most important developments of our times—nuclear energy and space flight.

Thus far, the enormous potential of nuclear energy has only been realized in situations where it produces destructive interactions with its surroundings. For almost all peaceful uses of nuclear energy, it is necessary to design devices fundamentally limited by the binding energy of solids. Fission reactors are severely limited by the temperature limitations of the solid materials of which they are constructed and the material limitations of the conventional power-conversion equipment used with present-day power reactors. Since this same conventional power equipment limits the performance and constitutes about half the cost of power generation from fossil fuels, it is not surprising that fission power is not cheaper than power from fossil fuels.

One of the great hopes for releasing fission reactors from the limitations of solid materials is the MHD generator. In an MHD generator, a plasma is formed by heating a gas, and then passing it through a strong magnetic field in which part of the thermal energy of the plasma is converted to electrical energy. In this device the temperature limitations of boilers and turbines are avoided, and it is possible to utilize the full high-temperature capabilities of a nuclear reactor. There is a minimum temperature required, however, to achieve sufficiently good gas conductivity to extract energy efficiently. This temperature is low enough so that there is hope of considerable improvement in the efficiency and in the capital cost of power generation from fission. It is probable that the earliest practical MHD generators will be combustion-driven. These devices—essentially a rocket engine discharging into the magnetic field—have gained tremendous help from rocket technology.

Looking like a fireball, a mirror reflects plasma in the channel of an experimental MHD generator.



Cavity Reactors Have Potential

Conventional fission reactors are limited by the properties of their fuel elements. The so-called cavity reactors, in which fissionable material is in gaseous form, may escape some of these limitations and make possible the achievement of temperatures of the order of 10,000 K from fission. Such reactors would combine very naturally with MHD generators and have considerable promise in the long-range future for achieving an important step toward abundant nuclear energy. The advent of space flight has required intensive research into the basic properties of gases in the range of temperatures up to 20,000 K. This knowledge is now being applied to the magnetohydrodynamic generator and may thus contribute to the achievement of cheaper energy from fission.

The temperatures needed for fusion reactions are many thousand times the highest temperatures at which solid materials are held together by chemical binding forces. The only promising technique for containing a fusion plasma is then provided by a magnetic field. Plasma at fusion temperatures is very different from the plasmas we have been discussing, in that deflection of particles by collisions with other particles is a comparatively rare event. Thus typical particles will have a mean free path of thousands of kilometers before being deflected by collision with other particles. These interparticle collisions are the prime sources of energy dissipation in ordinary gases and low-temperature plasmas.

The virtual disappearance of the collisional dissipation mechanism at high plasma temperatures is basic to the hopes that sufficiently good magnetic containment can be achieved to make a fusion reactor feasible. However, this very lack of dissipation processes has led to a host of instability problems which currently plague efforts to achieve fusion reactors. The interplanetary plasma is similarly free of collisional dissipation and, therefore, it is to be hoped that research on the interplanetary plasma will shed much light on the fundamental characteristics of these plasmas and will be instrumental in the achievement of fusion reactors.

Re-entry into the earth's (CONTINUED ON PAGE 118)

The economic impact of astronautics

Virtually everyone, from the scientist to the farmer, from the industrialist to the man at the machine, will enjoy some of the economic benefits of space exploration--and also carry a portion of the cost

By J. R. Dempsey

GENERAL DYNAMICS/ASTRONAUTICS, SAN DIEGO, CALIF.

J. R. Dempsey is president of GD/Astronautics and senior vice-president of General Dynamics Corp. A West Pointer, he commanded a P-38 photo reconnaissance squadron in England and France during WW II, and earned a master's degree in aeronautical engineering in the first class of the AF Postgraduate Missile Course at the Univ. of Michigan. In 1948 he was assigned to the Pentagon as guided missiles project officer and shortly thereafter became chief of all missile projects at AF Hq. He joined Convair (now GD/Astronautics) in 1953 as staff assistant to the vice-president and was placed in charge of the Atlas program the following year. An ARS Board member, he has drawn on his seven years of experience heading up one of the nation's largest missile-space booster programs in writing this thought-provoking article.

IN THE NEXT 10 years, the United States government will spend somewhere between $15 billion and $30 billion on military and peaceful uses of space. In the process, the government will have started one of the greatest economic upheavals in the history of mankind.

Within a decade, our annual space budget will probably top $5 billion. Almost every branch of our culture's economy will feel the impact. From the scientist to the farmer, from the industrialist to the man at the machine—virtually everyone in the nation will enjoy some of the advantages of space exploration, and also carry a portion of the cost burden.

At this point, no one can accurately forecast the long-term results of space exploration any more than Columbus could have predicted the impact of his voyages on the economics of the old world. However, it is possible to make a general estimate of the space-age economy as it will develop in the near future. Aiding in such an estimate is the fact that, for 10, 20, and perhaps even 50 years, the economy of astronautics will be tied almost exclusively to the government budget.

The only foreseeable exception is the employment of satellites for commercial communications, including voice, teletype, and television applications. Nevertheless, some day private enterprise may assume a role equal in stature to that of the commercial aircraft buyers.

Meanwhile, virtually every aerospace dollar will be a tax dollar, subject to public and congressional scrutiny. Unlike such industries as automotive or entertainment, which must account only to their stockholders, the space industry must explain its position in the economy to the entire nation.

Some Changes Can Be Accurately Predicted

How will space efforts change the economy here on earth? Will the average family live better because of this new science? Or will the taxpayers merely become collectively poorer by billions of dollars? In 50 years, we will know the answers for certain. Now we can only estimate, but a few dynamic changes can be accurately predicted.

Easiest to predict, perhaps, is the impact of space exploitation

from a purely military and defense industry viewpoint. While the military role of space planes, satellites, and moon bases is far from fully understood at this early date, most experts agree that military systems will not be restricted to ground bases for much longer. Many professional military people predict orbiting weapons will soon assume a deciding position in the cold war.

As a result, every indication suggests a steadily growing percentage of defense dollars will be for space. Next year, the Department of Defense will spend more than half a billion dollars on astronautics projects, and the billion-dollar mark will probably be passed in less than five years. The economic result will be a still greater shrinkage of the military aircraft market, but fortunately the industry recognized the trend early and appears geared for the change.

Influence Is Already Evident

However, the space age will go much deeper than just one industry. Even without a financial crystal ball, many of the influences are evident. For example, with the present state of the art, we know weather satellites are practical. The Congress recently approved an additional $75 million for this project. As proposed by President Kennedy, more than half is earmarked for the U.S. Weather Bureau for development of a global satellite network. One industry, agriculture, will feel the tremendous impact from man's first global look at the weather. Eventually, this new understanding of mankind's old Nemesis will lead to greater food production, a boon which in turn will demand some imaginative answers to the problems of distribution—answers which will feed the exploding population, or choke us with the surplus. Agriculture will enter the space age, it appears, with a need for an intellectual vigor to equal its inherent vitality.

Another industry that will rapidly come under the influence of space exploitation is that of communications. Current government spending in this area is approximately $100 million annually. An incredible advance has taken place in the communication field to achieve this degree of national support in less than one generation—a short time when we consider that President Hoover had the first desk telephone ever used in the White House. The communication satellite project is particularly interesting because it represents the first nongovernmental spending of any magnitude. Nine or 10 of the major communication companies are already planning to enter the field. (CONTINUED ON PAGE 112)

Space medicine and the future

It will go hand-in-hand with the astronauts as they journey into space, but will also impact directly on our everyday life on earth and touch on age-old questions of life processes

By W. Randolph Lovelace II and A. H. Schwichtenberg

LOVELACE FOUNDATION, ALBUQUERQUE, N. MEX.

Lovelace Schwichtenberg

W. Randolph Lovelace II, director of the Lovelace Foundation for Medical Education and Research, is a pioneer in flight medicine, a leader in the forming of aerospace medicine as a specialty, and a prominent member of the chief governmental councils responsible for policy in life science and human factors directly related to space flight. During World War II, he was chief of the surgical section of the Mayo Foundation, flight surgeon for the Army Air Force, and chief of the Aeromedical Laboratory at Wright Field. During the late 1940's and throughout the '50's, Dr. Lovelace participated actively in key AF, AEC, AMA, and NASA groups concerned with flight medicine and flight safety, including NASA's Special Committee on Life Sciences for Project Mercury. His national and international professional affiliations are virtually all-inclusive, and his awards number, among many others, the Collier Trophy (1940), the John Jeffries Award (1948), the Legion of Merit, the Distinguished Flying Cross, the Air Medal with three combat stars, and Sweden's Royal Order of the Sword.

Albert Schwichtenberg has been head of the Aviation and Space Dept. of the Lovelace Foundation since his retirement from the Air Force in 1958. During his distinguished military career, he served as FEAF Surgeon from 1946 to 1948, as chief of the Plans and Hospital Div. of the Army Surgeon General's Office from 1948 to 1949, on the Medical Policy Council of the Office of the Defense Secretary from 1949 to 1952, and as Command Surgeon of the Air Defense Command from 1952 to his retirement in 1958.

From a medical viewpoint the world is undergoing a scientific and technical revolution that will involve all aspects of human life. Research in aerospace medicine in particular will further worldwide improvements in the diagnosis and the treatment of disease and in the prolongation of life. Aerospace work, like that of medical research in general, however, will need longer lead-time than research in the physical sciences to come to fruition. Meeting the goals of space medicine will demand strong interdisciplinary support by scientists in many fields.

What is the context of aerospace medicine? NASA Director James E. Webb recently gave this context in terms of broad programs—determination of the environmental conditions in space; continuation of the man-in-space research program including orbital flights around the earth, manned space stations, and manned lunar and interplanetary exploration; greatly expanded worldwide communications through satellites; the development of new power sources, including nuclear, for use in space; determination of the intensity and character of different types of radiation in space; detection of the existence of life on other planets; and a better understanding of the origins of the solar system and the universe. We have already seen man and animals in space the subject of extensive medical examination and study.

Fortunately, the medical study of man in high-speed flight did not await man *ab ovo* in a space vehicle. For the past 12 years, the Lovelace Foundation, at the initial instigation of Brig. Gen. Don Flickinger, has had underway the development of a program of special examination and evaluation procedures for the determination of the state of the physical, mental, and social well-being of preselected subjects—intelligent, highly experienced pilots who are accustomed to the most complex and advanced aircraft, such as supersonic fighters and the X-15. The long-range objective of this program has been to ascertain whether a particular spacecrew member can live, observe, and do optimal work under stresses of space flight, as well as serve as an experimental subject. The technical means—movies and television—have been developed to allow scientific observation under the conditions of space flight.

A strong identity for aerospace medicine as a field developed concurrently with our space program, and was brought sharply into focus with the selection of the Project Mercury astronauts some two years ago, in a program directed by NASA and partici-

pated in by the Lovelace Foundation, Army, Navy, Air Force, AEC, NIH, and the NASA Space Task Group.

As far as can be ascertained, there has been no previous occasion when such a highly selected and technically capable group of men as the astronauts received such extensive clinical, laboratory, roentgenologic, physiologic, psychologic, and anthropometric evaluation. The successful flights of astronauts Shepard and Grissom confirmed the anticipated good results of this aerospace medical program. Moreover, we feel certain that the combination of many disciplines used in the examination and selection of the astronauts—and the establishment of new and improved criteria, along with improved roentgenologic and laboratory equipment—will be required in the future selection of spacecrews, including highly experienced pilots, physical and life scientists, and technicians.

From this background, aerospace medicine moves out both on a broad front and in select areas—from extensive and historically well-founded study in behavioral science to the question of extraterrestrial life. Let us look at some main lines of aerospace medicine and where they appear to lead. We can begin with the problem of aging, which cuts across our everyday interests as men and our professional interests in long space flights.

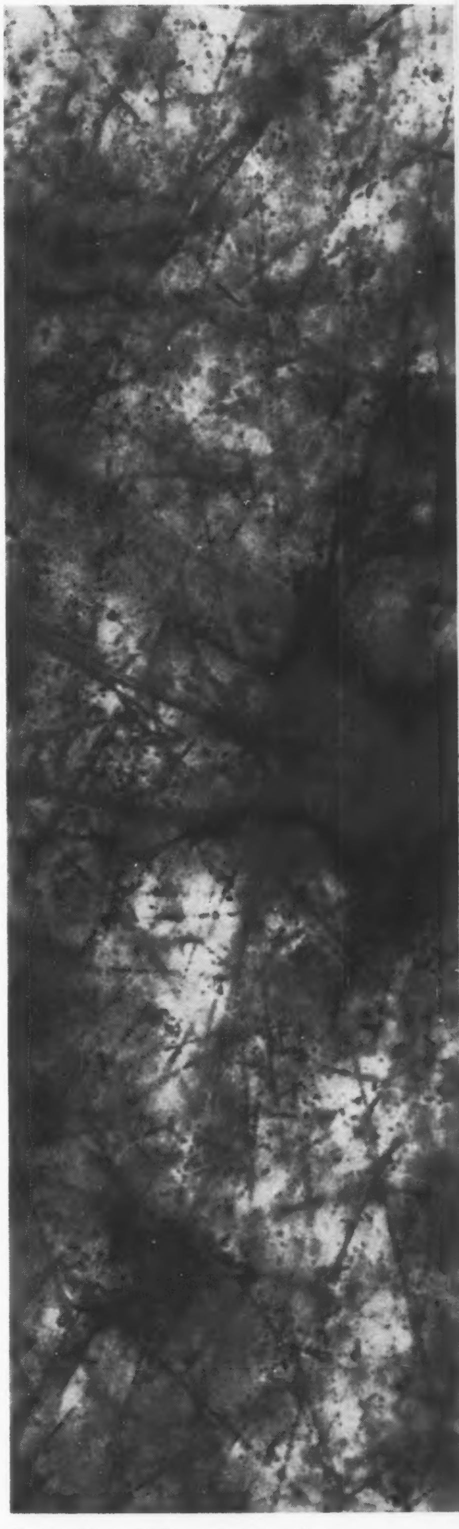
Aging. Hardin B. Jones, chairman of the Committee on Biological Research in Gerontology, defines aging as the progressive and usually irreversible diminution, with the passage of time, of the ability of an organism or one of its parts to perform efficiently or to adapt to changes in its environment. The consequence of all aging processes is manifested as a decreased capacity for functioning and for withstanding stresses, ending in the culminating disability that results in the death of the organism. The decreased capacity for functioning can be quantified in terms of measurable and functionally significant biological characteristics.

An Approach to Aging

Ultimately, a multi-disciplinary approach to the aging process as it affects spacecrews will be undertaken. The immediate goal will be to provide a performance decrement on the individual crew member in terms of his relative status as an aging human being, recorded in terms of five-year increments. It is believed that premature functional deterioration will be expressed initially in terms of premature physiologic aging. For each biological characteristic an exacting measuring technique will be employed. The biological techniques selected will include tests on the central nervous system, the cardiovascular system, the respiratory system, the renal system, the skeleton and integument, and the general systemic system.

Means are necessary for determining when the older crew member has reached an age when his years of experience no longer compensate adequately for performance degradation associated with the aging process itself.

Behavioral Science. During World War II, the Air Force conducted an extensive research program on the determination of the qualities of leadership and teamwork that produced outstanding bomber crews. This research on air crews and research on submarine crews by the Navy has produced excellent results, as exemplified by the recent 60-day (CONTINUED ON PAGE 98)



Protection of the astronaut from radiation such as these challenges aerospace medicine.

A social psychologist's view of astronautics

How realistic, how imaginative have we really been--technically, institutionally, personally, and socially, in the largest sense--in venturing into the space age?

By Donald N. Michael

THE PEACE RESEARCH INSTITUTE, WASHINGTON, D.C.

Donald Michael, one of the few well-qualified sociologists working in the space field, is the new director of research for the Peace Research Institute. Formerly senior staff member of the Brookings Institution, he authored the Brookings study for NASA on the implications of peaceful space activities for human affairs. Dr. Michael has been a consultant to numerous government agencies and groups, including the Civilian Defense Administration, the Dept. of Health, Education, and Welfare, the Walter Reed Army Institute for Research, and the National Science Foundation, and was a senior research associate with Dunlap and Associates. An electronics engineer for the Army in WW II, Dr. Michael received a B.S. in physics from Harvard Univ. in 1946 and a Ph.D. in social psychology there in 1952.

THIS SOCIAL PSYCHOLOGIST looking at astronautics—and there are very few social scientists doing so—is impressed more than anything else with the spectacular evidence it provides of the essential cultural and behavioral conservatism characteristic of all stable societies. Rather than demonstrating its ability to set society on new paths of excitement and enlightenment, astronautics so far, in the large, has been a powerful deepener of old ruts.

The possibilities we foresee and imagine for astronautics to enhance and broaden mankind have been explored in detail many times before. What is needed now is not the exhilaration of looking at where space and society *might* go. Rather, we need a sober examination of where space and society are *today*. For today's reality will profoundly affect the extent to which we can realize our hopeful fantasies about tomorrow.

A New Institution Raises Questions

In what follows we shall look all too briefly at several typical but important questions regarding the purposes and goals of astronautics, questions which have been begged or answered (or avoided) gratuitously via traditional beliefs and goals rather than on the basis of facts or careful planning worthy of the high challenge and opportunities astronautics provides.

We can begin with the popular posture, "prestige." In spite of the international, indeed cosmic, perspective appropriate to space activities, we still insist on a parochial viewpoint which equates what we believe other people think important with what we believe is important. As a result, there is a good part of the decision-making community—within astronautics and within the general political and public information environment in which it operates—which insists that our international prestige depends on what we do in space.

But does it? A good systems engineer would hardly set out to build equipment without first deciding what were the requirements to be met. Have we done this about prestige? Hardly! Do we even know what we mean when we speak of prestige? Do we want people to like us, to emulate us, to send their students to our schools, to buy their heavy equipment and instruments from us, to feel we

would win a war if a showdown came, or to turn their backs on offers and blandishments from the Communist bloc? And once we know what prestige is supposed to accomplish, do we know which groups or individuals we need to impress with our prestige in order to realize these accomplishments in specific countries? Do we know how space activities could most effectively fit into the over-all pattern of activities we might support, which could affect our prestige one way or the other—once we've defined what we want prestige to accomplish?

What facts there are indicate that the great "prestige" blow which the Soviets struck was that of incontrovertibility and forever demonstrating their technological maturity with Sputnik I. There is simply no foreseeable task which can be done in space which could deprive them of that image, especially since their technological accomplishments in other areas have been permanently and brightly illuminated by Sputnik I's existence. Subsequent space activities on both sides have made headlines to be sure, but there is no evidence that indicates that what nations do, with regard to us or the Russians, is in any simple sense a function of what we or the Russians do in space. But so far our willful ignorance of the social facts about prestige and our refusal to state explicitly what we want to accomplish by prestige has not stopped us from promising monumental space programs on gratuitous assumptions about implications they will have for our "prestige." If we continue to insist on acting on the basis of comfortable fancies rather than hard facts, our prestige efforts will continue to confuse both us and those we wish to (CONTINUED ON PAGE 119)

Space flight and the spirit of man

Space exploration will bring about a new Renaissance, but it will also upset many of man's present philosophical and religious beliefs . . . Nevertheless, to try to turn back now would be treason to the human spirit

By Arthur C. Clarke

Arthur C. Clarke, while best known for his science fiction and science writings, has long been associated with astronautics. After receiving his B.Sc. at King's College, London, he worked as an RAF radar officer with the Radiation Lab team on the prototype G.C.A. system, and in 1954 published the first paper on satellite communication systems. Twice chairman of the British Interplanetary Society, he was chairman of the Second IAF Congress in London in 1951 and of the Hayden Planetarium Symposium on Space Flight in 1954. He was for two years assistant editor of *Physics Abstracts* and is the author of 27 books and some 200 articles and short stories on astronautics, astronomy, and underwater exploring. His latest novel, "A Fall of Moondust," was published last month.

IT IS exactly 15 years since, at the October 1946 meeting of the British Interplanetary Society, I presented the first version of my paper "The Challenge of the Spaceship," an inquiry into the cultural and philosophical implications of astronautics. (The latest version is the opening essay in the book of the same name, published by Harper & Brothers in 1959.) At the time, as the title indicates, I was somewhat under the influence of Prof. Toynbee, having just attended a lecture he had given at the Univ. of London on "The Unification of the World." He had opened my eyes to the highly parochial view we westerners take of human history, which is best summed up by our attitude that *we* discovered the rest of the world.

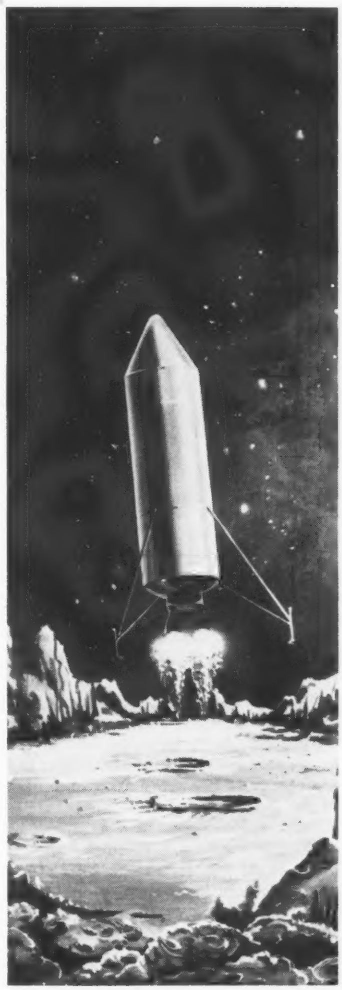
Above all, however, I was struck by Toynbee's emphasis on "Challenge and Response" as shaping the rise and fall of civilizations, and it seemed to me that we would be presented with a classic example of this when the space age opened. Here, without question, was the greatest physical challenge that life on this planet had faced, since the distant days when it emerged from the sea and invaded that other hostile environment, the arid, sun-scorched land.

As I went on to consider the possibilities opened up by this new field of exploration, my mind was inevitably drawn to the great voyages of discovery of the fifteenth and sixteenth centuries. These were not only voyages of discovery, but of escape; they liberated men's minds from the long trance of the Middle Ages, and fueled the fires of the Renaissance. Perhaps something similar would happen with space flight. Looking toward a future which, in 1946, still seemed very distant, I wrote the following words:

> "With the expansion of the world's mental horizons may come one of the greatest outbursts of creative activity ever known. The parallel with the Renaissance, with its great flowering of the arts and sciences, is very suggestive. 'In human records,' wrote the anthropologist J. D. Unwin, 'there is no trace of any display of productive energy that has not been preceded by a display of expansive energy. Although the two kinds of energy must be carefully distinguished, in the past they have been united in the sense that one has developed out of the other.' Unwin continues with this quotation from Sir James Frazer: 'Intellectual progress, which reveals itself in the growth of art and science . . . receives an immense impetus from conquest and empire.' Interplanetary travel is now the only form of 'conquest and empire' compatible with civilization. Without it, the human mind, compelled to circle forever in its planetary goldfish bowl, must eventually stagnate."

In later writings, notably the last chapter of "The Exploration of Space," I developed this idea a good deal further. My most carefully worked out analysis of the theme is the essay "Rocket to the Renaissance." This has probably been read by a substantial number of people in the astronautics business, even though it appeared in a

Space exploration offers man opportunities which far surpass even those provided by the great voyages of discovery of the 15th and 16th centuries, like that of Columbus in the *Nina*, *Pinta*, and *Santa Maria.*



journal more concerned with the biological than the physical sciences. (*Playboy*, July 1960.)

In any event, the concept is now part of the stock-in-trade of every thoughtful man concerned with space activities (see, for example, the editorial "The Second Renaissance" in the October 1960, *Astronautics*), and I feel a certain responsibility for having given it momentum. Now that we are well into the space age, and achievements which in 1946 seemed to belong to the remote future are milestones in the past, it is time to ask if these predictions of a cultural revival can still be justified—and even if they already show signs of coming true.

The World Is Not Yet Space-Minded

That the world is now space-conscious, to an extent which would have seemed unbelievable only a few years ago, is a statement that needs no proof. But it is not yet *space-minded*. By this, I mean that the general public still thinks of space activities almost exclusively in terms of military strength and international prestige. These matters are, of course, vitally important; yet in the long run, if there is a long run, they will be merely the ephemeral concerns of our neurotic age. In the sane society which we have to build if we are to survive, we must forget spacemanship and concentrate on space.

Unfortunately, altogether too many educators, intellectuals, and other molders of public opinion, still regard space as a terrifying vacuum, instead of a frontier with infinite possibilities. Typical of this attitude, though seldom so clearly (CONTINUED ON PAGE 90)

Outer space and the law: An engineering problem

The social engineering science known as "the law" must play its part, already long delayed, in determining whether an ordered society can function in space and on celestial bodies of unknown characteristics

By John Cobb Cooper

John Cobb Cooper is one of the world's most respected authorities on international air law. The first director of the Institute of International Air Law at McGill Univ., Montreal, Canada, from 1951 to 1957, he was a member of the Institute for Advanced Study at Princeton, N.J., from 1946 to 1951, and a vice-president of Pan-American Airways from 1934 to 1946. At present, he is legal adviser to the International Air Transport Assn. and a member of the Air Law Committee of the International Law Assn. He is a Fellow of the American Academy of Arts and Sciences and of the BIS, a member of the Executive Committee of the International Institute of Space Law, a member of the International Academy of Astronautics and of ARS, and Professor Emeritus of International Air Law, McGill Univ.

MAN IS INVOLVED today in one of the most revolutionary projects of recorded history: Seeking to expand our earthbound social structure into outer space.

The great "voyages of discovery" of our 15th and 16th centuries were courageous European efforts to find new routes to old civilizations in Asia, culminating by accident in expanding the European social structure to an already inhabited America. Phoenician voyages more than 2000 years earlier, into the Atlantic and thence south along Africa and north to Britain, were farsighted commercial ventures. Prehistoric migrations of unknown motivation were simply movements from one area to another in which man could still depend on earth, water, and breathable air.

Now we seek to determine whether an ordered society can be made to function in space beyond the air and on celestial bodies of unknown physical characteristics. In this project, the social engineering science known as "the law" must play its part, already too long delayed.

The term "law" may have a special significance to the scientist or the engineer. Roscoe Pound, for years Dean of the Harvard Law School, when discussing "Theories of Law" in his recent textbook on jurisprudence, noted that the word "law" is in use outside the field of the jurist. Thus, he points out, an old use is to mean the order of the universe, while a modern derivative use is to refer to "regular sequences of phenomena explained by a hypothesis of rules or principles underlying the sequences."

Dean Pound undoubtedly had in mind such rules as the "laws of motion," the "law of gravitation," and many others. The scientist and engineer know that these "laws" are ignored or violated at his peril. The sanction is real and may be disastrous: Professional failure and physical collapse of his project.

To the jurist, however, "the law" is the aggregate of a set of rules governing human conduct in society, many carrying sanctions to assure enforcement. Since early times, philosophers have disagreed as to exactly which rules are to be included. But, as Dean Pound also pointed out, a common use of the term "law" by jurists of all schools "is to refer to the regime of adjusting relations and ordering conduct by the systematic application of the force of a politically organized society." This is an engineering concept.

In 1947, Arthur L. Goodhart (now Master of University College, Oxford) contributed an essay to a volume in honor of Dean Pound, published under the title "Interpretations of Modern Legal Philosophies." Prof. Goodhart there defined law as a "rule of human conduct which is recognized as being obligatory." In referring to Dean Pound's development of the "engineering interpretation" of law, Prof. Goodhart said: "To describe law as a piece of social engineering is not to talk in terms of analogy; it is a statement of actual fact, for law is a framework without which a society cannot exist. If this framework collapses, then the whole society will collapse with it. In constructing our society . . . it is therefore necessary to plan the framework with care, because if it is too rigid or too limited or too weak, then our society will suffer from these defects."

The law now faces its own engineering problem in outer space. Prof. Goodhart's words are directly applicable. The basic and engineering sciences are already doing more than their part in providing needed vehicles and equipment, and in planning for the future. The medical, psychiatric, and biological sciences are going forward actively with the problem of adapting man to new conditions. Otherwise, human life, as we know it on our little speck of solid matter in the universe, cannot be maintained in outer space.

Only the social engineering science of the law has been slow in its task of providing adequate rules of human conduct. Further delay or eventual failure will lead to disastrous chaos. For, as Prof. Goodhart said, the law is the framework without which a society cannot exist, and, if the framework collapses, the whole society will collapse with it.

Further Delays Can Lead to Chaos

In my personal judgment, any sound and effective framework will require new international agreement, preferably on a worldwide basis. Time does not permit the gradual development of customary rules. The dynamism of high-altitude flight demands immediate consideration. It seems obvious that the legal social structure now applicable in the "airspace" adjacent to the earth cannot be adapted to outer space.

For many years, the legal principle has been accepted that each State is sovereign in the airspace over its national lands and waters, that its unilaterally determined laws and regulations apply there to the exclusion of all others and that it has the sole and exclusive right to permit, control, or deny flight in its airspace. On the other hand, over the high seas, the airspace is not part of the territory of any State and flight is open to all, as is navigation on the free seas. An aircraft in flight passing above one State and into the airspace over another State moves through an invisible boundary from one jurisdiction and legal regulation to another. Similarly, an aircraft moving from the airspace over a State to the airspace over the high seas faces the same situation.

Obviously such a system is impossible in outer space. If national sovereignty of any State extends indefinitely upward, chaos in outer space must follow. It will never be possible in practice to determine with accuracy when satellites and future spacecraft, traveling at tremendous speeds, pass from the operative area of one set of rules to that of another. The legal framework will collapse of its own inherent weaknesses. The first international task must therefore be to fix an upper limit to national sovereignty with its rights of unilateral regulation.

When this is done, an international decision must be reached as to how and by whom the rules of human conduct in outer space are to be fixed. This requires a decision as to the legal status of outer space. It is suggested (CONTINUED ON PAGE 104)

ARS Space Flight Report to the Nation

SFRN and the nation

ARS Coliseum exhibits will offer the public the first comprehensive display of new space-age products and byproducts, and review for the nonprofessional the true meaning of our efforts to move into space

By Wernher von Braun

DIRECTOR, NASA GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.

CHAIRMAN, ARS SPACE FLIGHT REPORT TO THE NATION COMMITTEE

October 1961 is not only the month of the American Rocket Society's unprecedented SPACE FLIGHT REPORT TO THE NATION but also the fourth anniversary of the space age. In the short period of time between the launching of humanity's first satellite in 1957 and the lunar, interplanetary, and man-in-space projects to which we are now becoming accustomed, truly staggering scientific and technological changes have been recorded—changes that, in one way or another, affect every man, woman, and child on our planet.

Based on what has been done and learned during these past four years, we confidently expect to continue to produce exciting new achievements along the ever-receding space frontier. Such achievements are a source of national pride, but they cannot be bought cheaply. Each American, directly or indirectly, must provide his very best efforts if our nation is to emerge as the leader in the exploration, and eventual exploitation, of the beckoning worlds in the solar system.

No amount of energy is too great if we are to realize this monumental task. The Soviet Union has amply demonstrated its determination, and ability, to move ahead swiftly and efficiently across a broad front of space science and technology. If any doubts lingered as to the extent of Russian developments, and the magnitude of their achievements, these were quietly and completely dispelled by the 25-hr orbital flight of cosmonaut Titov in the second Vostok satellite.

Important to National Prestige

Space is of transcendant importance not only to scientific progress but to national prestige and security, a fact long appreciated by the Soviet planners and only recently understood by the vast majority of Americans. As the President said several months ago in his second State-of-the-Union message, from now on we must consider space research and exploration to be "the very heart of our national policy," and it is time for "this nation to take a

clearly leading role in space achievement," which could "hold the key to our future on earth."

Space projects are expensive and eat up a healthy slice of our tax dollar. Nearly everyone knows this, and more or less takes it for granted. Not so widely known is the fact that space projects tend to pump back into the nation's economy more than they receive from it. At the present time, the gain from this "feedback" is not all in dollars and cents, but is often evident in new ideas, new concepts, new tools, and new methods of doing things.

The most obvious illustration of the importance of the space program to our nation is given by the magic word "money." Certainly, space projects cost money. But they also provide money, to thousands upon thousands of hard-working individuals and to hundreds of thousands, if not millions, of others who are indirectly affected. Hundreds, and often thousands, of contractors are required to provide the products and services to turn our space dreams into realities. It has been estimated that over 5000 industrial and other organizations in the U.S. derive a major portion of their income from space and space-related programs. Entire new industries have grown up in fields that were virtually unknown a decade ago—missiles, spacecraft, miniaturized electronics, novel propellants, ceramics, cryogenics, solid-state physics, high-speed computers, magnetohydrodynamics, and the like.

Today, we spend perhaps $4 billion a year on space projects, including civilian and military. Over the next five years, it is estimated that we shall expend, mostly to industry, some $25 to $30 billion; the lunar exploration program alone may cost up to $20 billion by 1970, which figures to be about $100 for each and every one of us, adult and child alike. Despite the cost, we shall probably return to our pockets at least double our contributions by providing an economy made vibrantly alive by the very projects it is undertaking. Economic growth is equivalent to national dynamism; economic decline, to national lethargy.

But suppose we take a negative view of space and decide we don't want any part of it. Is it hard to imagine what would happen if we were suddenly to downgrade, or even cancel, our missile, satellite, and space programs? Thousands upon thousands of us would be without work; our buying power would disappear, directly affecting our families and indirectly millions of other Americans whose livelihood depends upon us. But this is not all. Carefully built up skills and knowledge would be abandoned and perhaps forgotten. The incentive of young engineers and scientists to follow careers in the challenging new space endeavor would be destroyed almost overnight. The pioneering spirit of America, resting on a proud heritage, would flicker and die because its people turned their backs on the greatest of all frontiers. The nation that once tamed a hostile continent would have lost its energy, its will to conquer the unconquered, its determination to meet competition and triumph.

Great Inspirational Venture

Recently, the members of the Space Science Board of the National Academy of Science said that they regard "man's exploration of the moon and planets as potentially the greatest inspirational venture of this century, and one in which the entire world can share." This alone is a "payoff." If, in undertaking a great task, we can inspire our people with a magnificent and attainable goal, we may at the same time provide an entirely new meaning to their existence, a satisfaction of a basic instinct for the exploration of the unknown. Internationally, it may be possible to channel the energies of mankind away from cold wars and hot wars and into the greatest of all enterprises—(CONTINUED ON PAGE 95)

Wernher von Braun

Chairman

SFRN and the professional

Coliseum meeting offers the scientist and engineer an opportunity to review the latest work in his own specialty while becoming more familiar with the entire broad and complex field of space technology

By Harold W. Ritchey

VICE-PRESIDENT, THIOKOL CHEMICAL CORP., OGDEN, UTAH
PRESIDENT, AMERICAN ROCKET SOCIETY

To be able to use the words "space flight" and "professional" in the same breath is practically an innovation. Less than 10 years ago, those professionals giving serious attention to the conquest of space often were regarded by their colleagues as a part of the lunatic fringe of the scientific community. The mid '50's saw the dawning of the realization that there are good and valid reasons for space exploration.

Since Sputnik I, the conquest of space has not only become a respectable endeavor for the professional; it has become a national objective. In his message of May 25 to Congress, President Kennedy stated "it is time for this Nation to take a clearly leading role in space achievement." He further stated "we have never made the national decisions or marshaled the national resources for such leadership. We have never specified long-range goals on an urgent time schedule." He then defined the goals and told us that the decision to reach them demanded a major national commitment of scientific and technical manpower.

Offers Challenging Opportunities

The scope of the effort now planned for this Nation's space exploration program is overwhelming and presents to the professional in practically every branch of science and engineering opportunities which are challenging from every viewpoint. The range of scientific disciplines involved is generally represented by the 19 technical committees of the American Rocket Society.

The benefits to our Society and to our economy will be manifold. As in any other great cooperative endeavor for exploration and research, new discoveries and new products will extend to every phase of industrial activity, thereby continuing the change in our mode of everyday living.

Taking a longer-range view of the benefits of space exploration to humanity in general, it would appear that the continued expansion of the earth's population will generate an increasing pressure for room and materials which can be satisfied only by the effective conquest of space. As knowledge in our field progresses, conquest of space will achieve commercial feasibility and perhaps represent one of our earth's biggest single enterprises. Even in light of today's technology, it is worth reflecting that the energy content of an object traveling at escape velocity from the earth's gravitational field is contained in about 25¢ worth of our most commonly used rocket propellants. A figure of this kind cannot fail to stand as a challenge to our capable technologists—a challenge that will eventually result in the commercial feasibility of space travel.

In addition to the material benefits of space exploration, the psychological value to this nation, and indeed to all of mankind, cannot be overlooked. Although there are many problems yet to be surmounted, the basic technological groundwork has already been laid for manned lunar exploration. With the basic ability in existence, we as members of this great nation and indeed as members of the human race cannot refuse to accept this challenge. If it is not obvious to some that such an enterprise can be justified on the basis of economics, then this enterprise, like all other efforts to learn more of our environment, must initially be pursued with the one motivation of satisfying our curiosity.

Founded in 1930, the American Rocket Society has always recognized its obligation in the conquest of space. The Society exists for one principal purpose: To furnish the machinery for communication within and between the many scientific disciplines

essential to the success of space exploration. The Society stands ready, willing, and able to do its part to meet the national objective. It is to this end that we have organized and sponsored the SPACE FLIGHT REPORT TO THE NATION.

The SPACE FLIGHT REPORT TO THE NATION is the most significant event of its kind. It affords the professional an opportunity to review past accomplishments, current status, and plans for the future. The program is designed to fulfill the needs of the professional in his own specialty, as well as to offer an opportunity through the interdisciplinary sessions to review the broad and complex field called space technology. Further, the many and varied exhibits will enable the professional to see the fruits of the labors of his associates.

But perhaps the greatest benefit of all to the professional will be derived from the informal discussions, outside of the organized technical sessions, during which he will become better acquainted with his fellow scientists.

No Time for Complacency

With this great achievement by the American Rocket Society, and with public, national, and international acceptance of the importance of space exploration, this is no time for complacency, back-patting, or laurels-resting by the Society and its membership. The idea of space exploration, and our present concept of how it will be achieved, is only one step in the continual progress of the human race in its struggle to learn more about its environment. Let us not become staid or complacent in our success.

Now is the time to continue even more aggressively in facing the new and revolutionary challenges for the gamut of professionals who make up the engineering and scientific force of this country. Exploration of space with chemically powered rockets does not represent the end of human progress, nor does it represent the last opportunity available for major progress in science and engineering. ♦♦

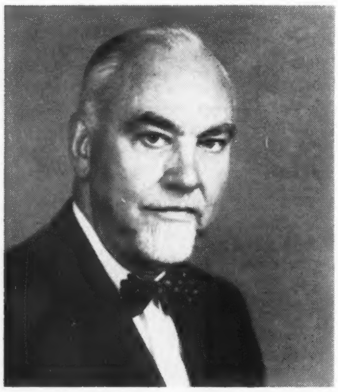
Harold W. Ritchey

ARS at 31

The Society bridges the eras--from science fiction to SFRN

By G. Edward Pendray

PENDRAY & CO., BRONXVILLE, N.Y.



G. Edward Pendray, one of the country's foremost proponents of space flight and rocket power, has been associated with the development of rockets for more than 30 years. A Founding Member of the American Rocket Society, he edited its technical publication, *AIS Bulletin* (now *ARS Journal*), for several years, and later served as ARS president, secretary, treasurer, and Board member. He is at present adviser to the Society on program development, publications, and public relations, and consultant to the Daniel and Florence Guggenheim Foundation, as well as senior partner of the management and public relations firm of Pendray & Co. Author of several non-fiction books, including "The Coming Age of Rocket Power" (1945) and "Men, Mirrors and Stars" (1935), he was also co-editor with Mrs. Robert H. Goddard of "Rocket Development," a book dealing with Dr. Goddard's experimental work. Dr. Pendray is a Fellow Member of ARS and AAAS, and a member of the National Science Writers Assn., the Public Relations Society of America, and other technical and professional societies.

FEW NEW ORGANIZATIONS are born with such vaulting ambitions—and such small resources—as the American Rocket Society, which came into existence on a pleasant evening in April 1930 in an apartment at 450 West 22nd Street, New York, N.Y.

Its founders were a dozen young, unknown, but boldly imaginative space-flight enthusiasts who for some time had been meeting informally to discuss the possibilities of astronautics. These discussions were sometimes made memorable with the aid of a gallon or so of red wine obtained from a speakeasy in the basement of the building.

The principal moving spirit of the group was David Lasser, now a labor union official. Lasser, who became the first president, had studied engineering at MIT, and, after a brief career in engineering and industry, was serving as managing editor of a pioneering science-fiction monthly called *Wonder Stories*. Most of the others in the founding group, some with technical backgrounds and some not, were occasional or frequent contributors to this publication. Through writing science-fiction stories, they had rather sold themselves on the scientifically disreputable notion that space flight was not only feasible but desirable.

No great idea can get very far without an organization behind it, as everybody knows. The founders of the Society set out to create that organization. And to make it perfectly clear what they were about, they boldly named it the American Interplanetary Society. In spite of much pressure—as late as May 1945, Robert H. Goddard was to write: "The subject of projection from the earth, and especially a mention of the moon, must still be avoided in dignified scientific and engineering circles"—the name stuck for four years. At the annual meeting of 1934, it was quietly changed to the American Rocket Society. The Society's publication explained that "in the opinion of many members, adoption of the more conservative name, while in no way implying that we have abandoned the interplanetary idea, would attract able members repelled by the present name."

Shortly after the founding, the Society issued its first news release.

"It is our aim," said the release, "to build this society into a national organization, with financial and other resources such that we can offer real inducement and stimulation to American scientists, com-

BULLETIN

THE AMERICAN INTERPLANETARY SOCIETY

302 West 22nd Street, New York, N.Y.

David Lasser, President — C. W. Van Devander, Editor

No. 1. — New York — June, 1930

INTRODUCTORY

Among the principal aims of the American Interplanetary Society are the promotion of interest in interplanetary exploration and travel, and the mutual enlightenment of its members concerning the problems involved. To these purposes the monthly bulletins, of which this is the first, will be devoted.

The Society, despite its youth, has already begun to tackle seriously the peculiar problems in its field. Since the creation of public interest is of prime importance, the Society has sought to awaken interest in itself as well as the ideas for which it stands. Meanwhile, it has also begun the scientific consideration of the technical side of its program.

These varied activities will be reported here in full. In addition the bulletin will contain comprehensive summaries of developments relating to its subject everywhere in the world. The foreign news is expected to be of particular interest and value, and every effort will be made to make it a complete record of the research and experiments of foreign scientists in this field. All suggestions for improving the bulletin will be gratefully received.

NEWS OF THE SOCIETY

One of the earliest books on the subject of interplanetary travel, written by John Wilkins, Bishop of Chester, in 1640, has become the property of the Society through the generosity of one of its members, Hugo Gernsback. Captain Sir Hubert Wilkins, noted explorer and a descendant of the author, who is an honorary member of the Society, made the presentation in a ceremony at the American Museum of Natural History on April 30, David Lasser, president, receiving the small leather bound volume for the Society. The book, entitled, "The Discovery of a New Eorld, or a Discourse Tending to Prove That There May Be Another Habitable World in the Moon, and Concerning the Possibility of a Passage Thither," becomes a valuable part of the Society's library.

- - - - - - - - - - -

A survey of the entire field of information relating to interplanetary travel has been begun by the Society, with C. P. Mason in charge of the investigation. It is the purpose of the survey to bring together in a comprehensive collection all the writings on that and related subjects, and to outline the problem with all its attendant difficulties, together with the proposals that have been made to solve them. The result should provide a complete reference library on the subject and a guide for scientists and others who may be interested.

Left, first page of the *Bulletin* of the American Interplanetary Society, now ARS, announcing formation of the Society and its aims. Above, left to right, John Shesta, the author, and Bernard Smith pressurize ARS Experimental Rocket No. 3 prior to static tests at Great Kills, Staten Island, N.Y., in September 1934.

parable with that offered to scientists in Germany, Austria, and France, in the development of rockets, rocket-cars and other proposed methods of traveling in space . . .

"It is not generally understood, though it is a fact, that the shooting of a projectile to the moon or another planet—even a projectile bearing human beings—is now largely a matter of brute power—of finding an explosive light enough, yet powerful enough, to yield the necessary velocity . . .

"The members of the American Interplanetary Society feel there is room for a group which will take an active part in encouraging research in this direction."

To this announcement the *New York Herald Tribune* gave nearly a column of space. The New York afternoon papers also gave it a play. But the august *New York Times* considered it beneath notice and did not, as a matter of fact, say anything about the Society until some six months later, when, in an editorial, it struck what has since become a somewhat hackneyed note:

"It would be interesting to know the reach of the researches of the American Interplanetary Society . . . But what we need most of all now is an American Planetary Society, to emphasize our taking a greater concern in this planet's affairs."

The first issue of the Society's publication, then called the *AIS Bulletin* but now known as the *ARS Journal* (such is progress!) appeared in June 1930. It was a four-page mimeographed newsletter, produced personally by Lasser on a borrowed mimeograph machine. Smudgy in appearance, but bold in tone, it announced that (CONTINUED ON PAGE 202)

The SFRN technical program

BANQUET SPEAKER

Vice-President Lyndon B. Johnson

THE TECHNICAL PROGRAM for the American Rocket Society SPACE FLIGHT REPORT TO THE NATION, to be held at the New York Coliseum October 9-15, is not only the largest in the Society's 31-year history, but is also expected to provide the expected attendance of 15,000 engineers and scientists with a threefold review of astronautics and rocketry.

As ARS President Harold W. Ritchey points out in his article on page 68, SFRN was planned from the outset as a three-in-one meeting for the professional. First, he would have an opportunity to keep up to date on developments within his own area of specialization; second, through the medium of special interdisciplinary sessions, he would be able to get a broad look at how the various disciplines which go to make up astronautics combine in specific vehicle systems and how these vehicles will be used for specific missions; and, third, through the astronautical exposition, he would have a chance to see some of the actual handiwork of his colleagues.

Thus the size and the scope of the technical program for the meeting was dictated in advance by its threefold purpose. The effort involved in setting up the program may be judged by the fact that it has been well over a year in the making under the direction of ARS National Program Chairman George Gerard of New York Univ.; Jerry Grey of Princeton's Forrestal Research Center, chairman of the SFRN Space Flight Panels; and the ARS Technical Committees.

The technical program for the meeting consists of some 53 sessions covering all the astronautical disciplines, at which more than 250 papers will be presented. The sessions will all be held in six spe-

New York Coliseum, scene of the ARS SPACE FLIGHT REPORT TO THE NATION, October 9–15, 1961.

ARS SPACE FLIGHT REPORT TO THE NATION

OCTOBER 9-15, 1961

Session Outline

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
9:00 MORNING	**Robot Exploration** (Jack Froehlich) 4 **Logistics and Operational Problems of Very Large Booster Systems** (Phillip F. Fahey) 3 **Structures and Materials** (Ernest E. Sechler) 5 **Power Sources for Electric Propulsion** (John Evvard) 6 **Nuclear Rocket Mission Applications** (Robert Trapp) 2 **Astrodynamics** (Samuel Herrick) 1	**Human Factors and Bioastronautics** (Brig. Gen. Charles Roadman) 3 **Missiles and Space Vehicles** (Maxwell Hunter) 4 **Power Systems** (Major W. G. Alexander) 5 **Electrothermal and Electromagnetic Thrust Generation** (Mark Ghai) 6 **Nuclear Instrumentation** (Andrew M. Koonce) 2 **Hypersonic Heat Transfer and Vaporization Ablation** (C. F. Hansen) 1	**Missiles and Space Vehicles** (Carl Kober) 4 **Environment of Space** (Joseph Kaplan) 3 **Electric Propulsion Missions** (Capt. Richard Hayes) 5 **Guidance and Control, State-of-the Art Review** (James S. Farrior) 6 **New Liquid Rocket Techniques** (Paul D. Castenholz) 2 **Hypersonics** (William H. Dorrance) 1	**Communication Satellite Future Programs** (Frank Lehan) 4 **Environment of Space** (Sidney Sternberg) 3 **Advanced Guidance Devices** (Charles E. Durham) 5 **Design of Electric Propulsion Spacecraft** (Geoffrey Robillard) 6 **NASA Program Report** (Milton Rosen) 2 **Space Propulsion and Components** (H. G. Jones) 1	**Propulsion System Selection** (Arch C. Scurlock) 4 **Environment of Space** (Jack Ruina) 3 **Propellant Technology for Space Application** (Gerald Morrell) 5 **Magnetohydrodynamics** (Milton M. Slawsky) 6 **Space Law and Sociology** (Robert D. Crane) 2 **Post Injection Guidance Considerations** (Charles E. Durham) 1	SPACE EDUCATION DAY	FINAL DAY OF EXHIBITS
12:15	LUNCHEON	LUNCHEON	LUNCHEON	LUNCHEON	LUNCHEON		
2:30 AFTERNOON	**Instrumentation for Manned Space Flights** (Col. John P. Stapp) 4 **Current State-of-the-Art of Missile and Space Vehicle Flight Testing** (Lt. Col. P. B. Peabody) 3 **Structures and Materials** (Ernest E. Sechler) 5 **Electrostatic Thrust Generation** (A. T. Forrester) 6 **Propulsion Reactor Op. Problems & Facilities** (Gaylord Newton) 2 **Astrodynamics** (G. Leitmann) 1	**Human Factors and Bioastronautics** (Brig. Gen. Ted Bedwell, Jr.) 4 **Military Program Review** (Col. Harry Evans) 3 **Power Systems** (U. B. Thomas) 5 **Electric Propulsion Testing** (Robert Supp) 6 **Communication Satellite Current Programs** (William Pickering) 2 **Hypersonics** (Walter R. Warren) 1	**Space Flight Report Panels** **The Vehicles** (Krafft Ehricke)	**The Missions** (Arthur Kantrowitz)	**The Global Effects** (James Doolittle)		
7:30 EVENING	**Evolution of American Liquid Propellant Rocket Engines** (Robert C. Truax) 4 **Continuing Education** (Vince Haneman) 3 **Electric Propulsion Panel** (Ernst Stuhlinger) 5 **Astrodynamics** (Robert M. L. Baker, Jr.) 2	**Human Factors Panel** (Eugene B. Konecci) 4 **Space Law and Sociology** (Andrew G. Haley) 3 **Technical Information: The Paper Curtain** (Sheldon Isaacson) 5 **Power Systems** (G. M. Anderson) 2		The U.S. and U.S.S.R. Space Programs: A Critical Evaluation	**SFRN BANQUET**		

Session Chairmen denoted by parentheses ( ) Numerals indicate Session Rooms.

SFRN Interdisciplinary Sessions

Wednesday, October 11

THE VEHICLES

2:30 p.m. **Rooms 3 and 4**

Moderator: Krafft Ehricke, program director, Centaur Program, General Dynamics/Astronautics, San Diego, Calif.

Panelists:

Vehicle Systems
Willis M. Hawkins, vice-president and assistant general manager, Lockheed Missiles and Space Co., Sunnyvale, Calif.

Chemical Propulsion
Martin Summerfield, professor of aerospace propulsion, Princeton Univ., Princeton, N. J.

Advanced Propulsion
R. W. Bussard, Nuclear Propulsion Div., Los Alamos Scientific Laboratory, Los Alamos, N. M.

Guidance and Control
C. Stark Draper, head, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, Mass.

Launch Operations
Kurt H. Debus, director, Launch Operations Directorate, George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Huntsville, Ala.

Special Vehicle Problems
Norris F. Dow, consulting engineer, Space Sciences Laboratory, General Electric Co., Philadelphia, Pa.

Thursday, October 12

THE MISSIONS (NON-MILITARY)

2:30 p.m. **Rooms 3 and 4**

Moderator: Arthur Kantrowitz, director, Avco Everett Research Laboratory, Everett, Mass.

Panelists:

Sounding Rockets and Scientific Satellites
Herbert Friedman, superintendent of Astrophysics and Atmosphere Div., U. S. Naval Research Laboratory, Washington, D. C.

Solar System Exploration (Lunar and Planetary Probes)
William H. Pickering, director, Jet Propulsion Laboratory, Pasadena, Calif.

Meteorological Applications
F. W. Reichelderfer, chief, U. S. Weather Bureau, Washington, D. C.

Communications Applications
John R. Pierce, director of research, Bell Telephone Laboratories, Murray Hill, N. J.

Manned Space Flight
Robert R. Gilruth, director, Project Mercury, Space Task Group, National Aeronautics and Space Administration, Langley Field, Va.

cially constructed rooms on the fourth floor of the Coliseum (see page 75) from Monday through Friday, October 9 to 13. Six concurrent sessions will be held each morning during the week and on Monday and Tuesday afternoon, with the afternoon sessions on Wednesday, Thursday, and Friday set aside for the three interdisciplinary sessions. In addition, evening sessions are scheduled for Monday, Tuesday, and Thursday, while the Banquet will be held on Friday evening. (See page 73 for Session Outline.)

While it would obviously be impossible even to attempt to run down the entire technical program in this space, the unique quality of the meeting can be judged by what is being done at some of the sessions. For example, at its two sessions on Monday afternoon and evening, the ARS Structures and Materials Committee will present one-hour lectures by outstanding authorities in the field which summarize recent activities in their areas of cognizance, while referring to a large number of papers accepted by a review committee. The Astrodynamics Committee has similar programs planned for its two Monday sessions.

Other ARS Technical Committees have planned different approaches, with panel discussions especially popular. Thus the Test, Operations, and Support Committee will present a panel discussion of "The Launch Operations Challenge" at its Monday afternoon session, while the Electric Propulsion Committee will devote its entire Monday evening session to such a discussion and has also scheduled a panel on late events in the field at its Wednesday morning session.

There will also be a considerable number of review and state-of-the-art sessions, such as the Tuesday morning and afternoon sessions of the Power Systems Committee, and the military program review covering Discoverer, Tiros, and Advent on Tuesday afternoon, and the sessions on current and future communication satellite programs on Tuesday afternoon and Thursday morning. The full-scale review of the Environment of Space planned for Wednesday, Thursday, and Friday mornings promises to be outstanding as it moves from the earth's atmosphere and ionosphere through the interplanetary medium and out to the moon and planets. The Guidance and Control Committee also has a state-of-the-art session planned for Wednesday morning, while a NASA program report which will cover Centaur, Ranger, Saturn, and Mercury-Redstone is set for Thursday morning.

Another unusual session is planned for Monday evening, when

Friday, October 13

THE GLOBAL EFFECTS

2:30 p.m. **Rooms 3 and 4**

Moderator: James H. Doolittle, Chairman of the Board, Space Technology Laboratories, Inc., Los Angeles, Calif.

Panelists:

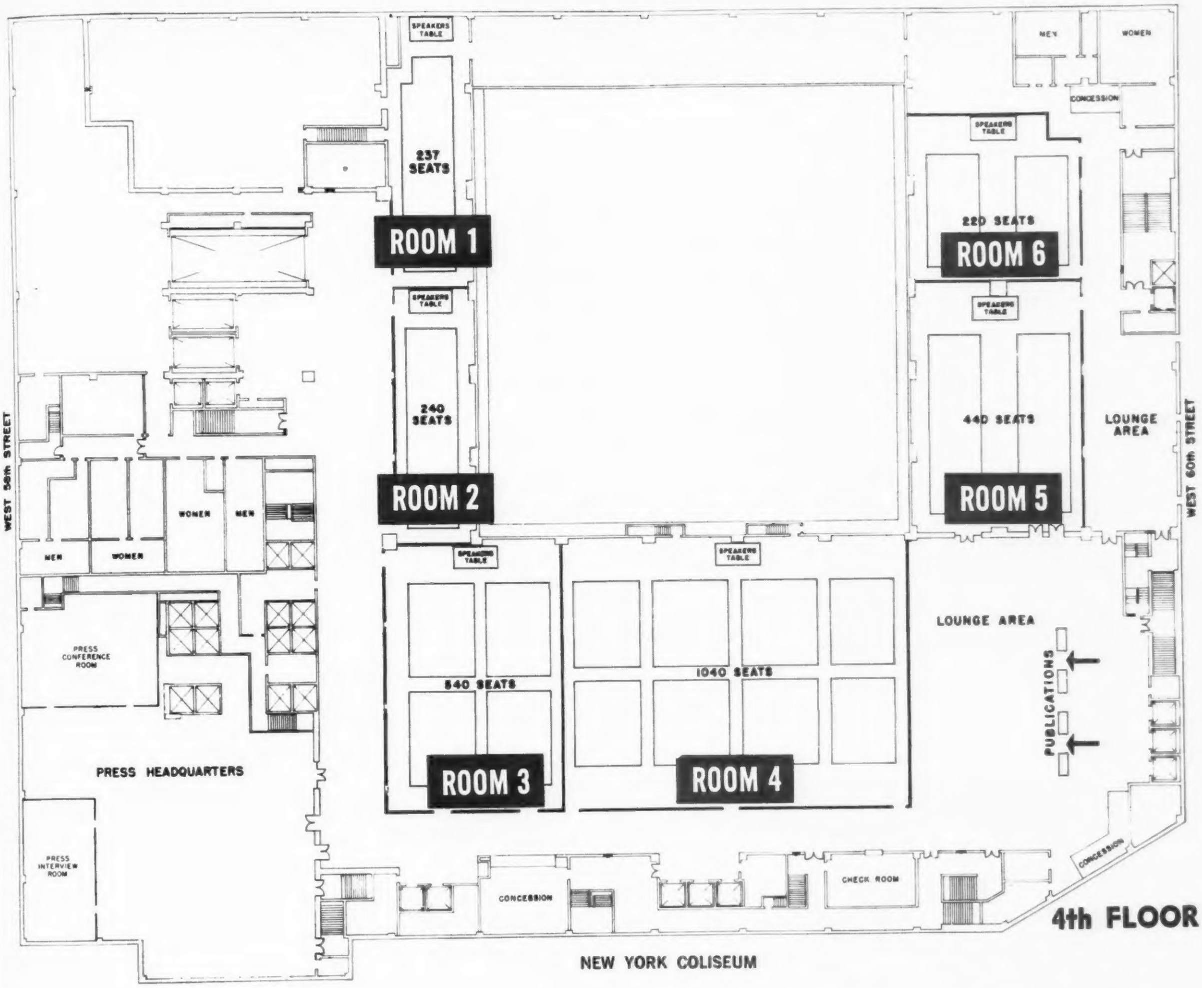
Military Effects
Trevor Gardner, president, Hycon Manufacturing Co., Monrovia, Calif.

Political Effects
Oskar Morgenstern, Econometric Research Program, Princeton Univ., Princeton, N. J.

Industrial Economic Effects
Donald Mitchell, vice chairman of the board, General Telephone and Electronics Corp., New York, N. Y.

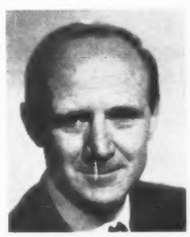
International Cooperation
Tunis A. M. Craven, commissioner, Federal Communications Commission, Washington, D. C.

Extraterrestrial Contact
Philip Morrison, professor, Laboratory of Nuclear Studies, Cornell Univ., Ithaca, N. Y.



NEW YORK COLISEUM

SFRN LUNCHEON SPEAKERS


William H. Pickering


James E. Webb


Lt. Gen. Bernard A. Schriever


Simon Ramo


Sen. Jacob K. Javits

MEETING CHAIRMEN

George Gerard
ARS Program Committee Chairman

Jerry Grey
SFRN Space Flight Panels Chairman

the Liquid Rockets Committee will present the first full-scale rundown on the evolution of the American liquid-propellant rocket engine, from the pre-WW II days to post-ICBM engines and what the future is likely to produce.

While evening sessions are designed primarily for the nonprofessional, many of these sessions (see page 82), as well as Space Education Day on Saturday, October 14 (see page 83), will be of equal interest to the professional.

Technical sessions throughout the meeting are studded with papers of unusual interest. The Robot Exploration session on Monday morning, for example, will include discussions of land locomotion on the surface of a planet and controlling a lunar vehicle from earth. The session on Logistics and Operational Problems of Very Large Boosters at the same time will discuss large booster recovery techniques and the question of whether there will be 100-million-lb space vehicles.

Other sessions, in addition to those already mentioned, will cover such subjects as Power Sources for Electric Propulsion, Nuclear Rocket Mission Applications (including a discussion of RITA, the re-usable interplanetary transport), Instrumentation for Manned Space Flight, Electrostatic Thrust Generation, Propulsion Reactor Operation Problems and Facilities, Human Factors and Bioastronautics, Missiles and Space Vehicles (including a discussion of zero-g propellants in space powerplants and a paper on "How Much Space Flight Can We Afford?"), Space Law and Sociology, Hypersonics, Advanced Guidance Devices, New Liquid Rocket Techniques for Space, Design of Electric Propulsion Spacecraft, Advances in Magnetohydrodynamics, and Propellant Technology for Space Applications.

Every one of the 19 ARS Technical Committees with the exception of the Ramjets and Underwater Propulsion Committees is represented on the technical program for the meeting.

Of special importance on the program, since they represent one of the first major attempts to unify the many and varied disciplines which make up astronautics, are the three interdisciplinary space flight panels scheduled for Wednesday, Thursday, and Friday afternoons (see page 74). Organized by Dr. Grey, they will bring together distinguished authorities from industry and government to discuss three major aspects of the space exploration program—the Vehicles, the Missions (non-military), and the Global Effects. The panels will be moderated by Krafft Ehricke, Arthur Kantrowitz, and Lt. Gen. Bernard A. Schriever respectively, and each is expected to attract an attendance of well over a thousand.

Not exactly a part of the technical program itself, but in this particular instance an important part of the SPACE FLIGHT REPORT TO THE NATION, are the five SFRN luncheons, to be held in a special area on the third floor of the Coliseum. The luncheon addresses, to be delivered by five prominent figures, will constitute the responses of the individual scientist and engineer, industry, educational institutions, the military, and NASA to the plea of President Kennedy for a sense of dedication in the U.S. space program, contained in his May 25th Special Message to Congress on Urgent National Needs (see the Message from the President on page 41).

The meeting will be climaxed by the Annual Honors Night Banquet on Friday evening, October 13.

All in all, the technical program for SFRN shapes up as the largest, the most comprehensive, and the most interesting ever prepared for an astronautical meeting in this country. ♦♦

The SFRN astronautical exposition

The SFRN astronautical exposition, to be held at the New York Coliseum October 9–15, will be the largest exhibit ever held devoted solely to rocketry and space flight, offering a full-scale, comprehensive display of present and future space capsules, spacecraft, satellites, boosters, missiles, and components.

More than 200 organizations will exhibit their latest developments on the first three floors of the New York Coliseum. The total exhibit area will be six times greater than at the largest previous ARS exhibit, at the 15th annual meeting of the Society in Washington, D.C., last year.

The seven-day schedule of exhibiting hours has been arranged so as to permit the professional an uninterrupted opportunity to view the exhibits in detail during the day, and to allow both the professional and public audiences extended viewing during the evening.

Designed to present the astronautics industry as a unified whole, the focal point of the Exposition will be an exhibit by NASA, 88 x 55 ft in size, on the spacious second floor of the Coliseum. The NASA exhibit will feature a Mercury capsule, a scaled-down version of the Saturn/Apollo, and cutaway versions of several NASA rockets. Full-scale versions of the Scout and Redstone-Mercury will be on display outside the Coliseum.

Surrounding NASA's central display will be large island exhibits, with the exception of those around the perimeter of the floor, arranged along broad radiating aisles. Aisles on this floor will be widened up to 50% above standard aisle widths, and ceiling height limitations will be removed to make a more effective presentation of a space panorama to visitors.

Exhibit Hours

Monday, Oct. 9	
Profession only	11 a.m. to 5 p.m.
Profession and public	5 p.m. to 10 p.m.
Tuesday, Oct. 10, through Friday, Oct. 13	
Profession only	10 a.m. to 5 p.m.
Profession and public	5 p.m. to 10 p.m.
Saturday, Oct. 14	
Profession and public	10 a.m. to 10 p.m.
Sunday, Oct. 15	
Profession and public	1 p.m. to 8 p.m.

Among the displays on the second floor will be:

- United Technology's exhibit of a large conical shaped segmented solid booster
- A mockup of a lunar-landing vehicle, displaced by Hughes
- The Advent satellite, shown by General Electric
- Titan II's segmented solid booster, exhibited by Aerojet
- A cutaway version of GM's projected electrical power unit for space travel
- McDonnell's Mercury capsule with escape tower, and special couches used by astronauts
- Full-scale model of the Saturn boat tail, displayed by Rocketdyne

On the first and third floors of the Coliseum a new exhibiting technique will be introduced. Displays will be arranged to allow visitors to pass through the middle of the exhibits, with each exhibitor having booth space on both sides of the aisle, rather than a standard arrangement along a single side. The new system, known as "Exhibiting in Depth," will allow visitors to pass through an ordered series of booths, each a unit in itself. The impression will be much the same as passing from room to room in a house.

On the first floor, North American Aviation will have the largest of these exhibit-in-depth booths, 100 x 60 ft, including aisles. Among North American's exhibits will be its 1.5-million-lb-thrust engine —the F-1; a scaled-down version of the X-15; and the proposed recoverable Saturn booster with paraglider attachment.

Exhibits presently indicated for display by other companies on the first and third floors are:

- B. F. Goodrich's model ion engine and a Mercury spacesuit
- Space Technology Laboratory's low-thrust propellant system for the Able-V final stage
- Republic's new plasma-pinch engine for attitude control
- Marquardt exhibits of aerospace propulsion, electrical propulsion, and nuclear propulsion
- Sundstrand's scale model of a solar dynamic power system

Special information centers will be set up at strategic locations where maps and other aids will be provided to help visitors find booths of special interest.

A complete list of exhibitors and booth numbers, and floor plans of the first, second, and third floors of the Coliseum will be found on the next four pages.

SFRN Exhibitor Listing

First Floor (Booths 100–283)

Firm	Booth No.
Acoustica Associates, Inc.	139
Aeroquip Corp.	173
Airborne Instruments Laboratory	197
Air Reduction Co.	176
Aluminum Co. of America	193
American Machine & Foundry Co.	211
American Optical Corp., J. W. Fecker Div.	141
Atlantic Research Corp.	143
Avica Corp.	156
Ball Brothers Research Corp.	232
Barber-Colman Co.	166
Barnes Engineering Co.	106
Bendix Corp.	175
Black, Sivalls & Bryson, Inc.	186
Borg-Warner Controls	144
Bramley Machinery Corp.	241
Brooks & Perkins, Inc.	160
Brush Beryllium Co.	164
Chandler Evans Corp.	238
Curtiss-Wright Corp.	213
Designers for Industry, Inc.	205
Deutsch Fastener Corp.	236
Donner Scientific Co.	219
Douglas Aircraft Co., Inc.	209
Edmund Scientific Co.	243
Electro-Optical Systems, Inc.	189
Electro-Thermal Industries	158
Firewel Co., Inc.	107
Flodyne Controls, Inc.	125
Garrett Corp.	154
General Astrometals Corp.	155
Globe Industries, Inc.	135
B. F. Goodrich Co.	273
Haberstroh Studios	161
Heinicke Instruments Co.	157
Hi-Shear Corp.	240
Johns-Manville Sales Corp.	228
Kollsman Instrument Corp.	145
LeFiell Mfg. Co.	235
Linde Co., Div. Union Carbide Co.	230
Lionel Corp.	151
Lukens Steel Co.	271
Magnaflux Corp.	259
Marotta Valve Corp.	260
The Marquardt Corp.	234
Minneapolis-Honeywell Regulator Co.	191
North American Aviation, Inc.	128
Olin Mathieson Corp., Ramset Div.	124
Packard-Bell Computer Corp.	168
Perkin-Elmer Corp.	123
Philco Corp.	117
Plasmadyne Corp.	172
Potter Aeronautical Corp.	153
Radiation, Inc.	142
Radio Corp. of America, Electronic Data Processing Div.	256
Raybestos-Manhattan, Inc.	198
Republic Aviation Corp.	195
Rohr Aircraft Corp.	204
Schonstedt Engineering Co.	159
Scientific American	199
Scientific Industries, Inc.	202
Space Aeronautics	138
Space Age News	162
Space Technology Laboratories, Inc.	104
Stauffer Chemical Co.	275
Taber Instrument Corp.	233
Technology Instrument Corp. of Acton	179
Tempil Corp.	182
H. I. Thompson Fiber Glass Co.	269
Thompson Ramo Wooldridge, Inc.	215
Unilectron, Inc.	109
United Systems Corp.	180
Walter Kidde & Co., Inc.	264
Waugh Engineering Co.	225
Wyle Laboratories	250
Wyman-Gordon Co.	252

2nd Floor (Booths 300–445)

Aerojet-General Corp.	345
Aerospace Corp.	320
Allied Chemical Corp.	335
American Rocket Society	376
American Telephone & Telegraph Co.	370
Avco Corp.	380
Beckman & Whitley, Inc.	310
Bell Aerosystems Co.	300
Boeing Co.	410
Burroughs Corp.	372
General Dynamics/Astronautics	350
General Electric Co.	360
General Electric Co., Missile and Space Vehicle Dept.	365
General Motors Corp.	420
General Telephone & Electronics Corp.	325
Grumman Aircraft Corp.	355
Haveg Industries, Inc.	432
Hughes Aircraft Co.	339
IBM Federal Systems Div.	397
Lear, Inc.	305
Litton Systems Inc.	378
Lockheed Missiles & Space Co.	337
Martin Co.	385
McDonnell Aircraft Corp.	415
NASA and DOD	400
Radio Corp. of America	375
Raytheon Co.	395
Rocketdyne Div. of North American Aviation, Inc.	401
Rocket Power, Inc.	435
Sperry Rand Corp.	330
Thiokol Chemical Corp.	430
United Aircraft Corp.	390
Vitro Corp. of America	315
Westinghouse Electric Corp.	405

3rd Floor (Booths 500–645)

Academic Press, Inc.	509
ACF Industries, Inc.	576
Aeroscience, Inc.	548
Aircraft & Missiles	558
Aviation Week	556
Beckman Instruments, Inc.	517
Beryllium Corp.	534
Blaw-Knox Corp.	513
Callery Chemical Co.	546
Chance-Vought Corp.	599
Chrysler Corp.	545
Electro Tec Corp.	530
General Precision, Inc.	582
Grand Central Rocket Co.	624
Librascope Div., General Precision Laboratories, Inc.	550
McCormick Selph Associates	531
McGraw-Hill Book Co., Inc.	557
MSA Research Corp.	601
Metco, Inc.	645
National Research Corp.	528
Naval Propellant Plant	554
Northrop Corp.	586
Ordnance Associates, Inc.	578
Pergamon Press, Inc.	532
Prentice-Hall, Inc.	560
Resistoflex Corp.	602
Royal Research Corp.	598
Sealol, Inc.	603
Space Electronics Corp.	523
Standard Oil Co. (N.J.)	592
Sundstrand Aviation Div., Sundstrand Corp.	542
Texaco Experiment Inc.	580
E. B. Wiggins Oil Tool Co., Inc.	518
John Wiley & Sons, Inc.	564

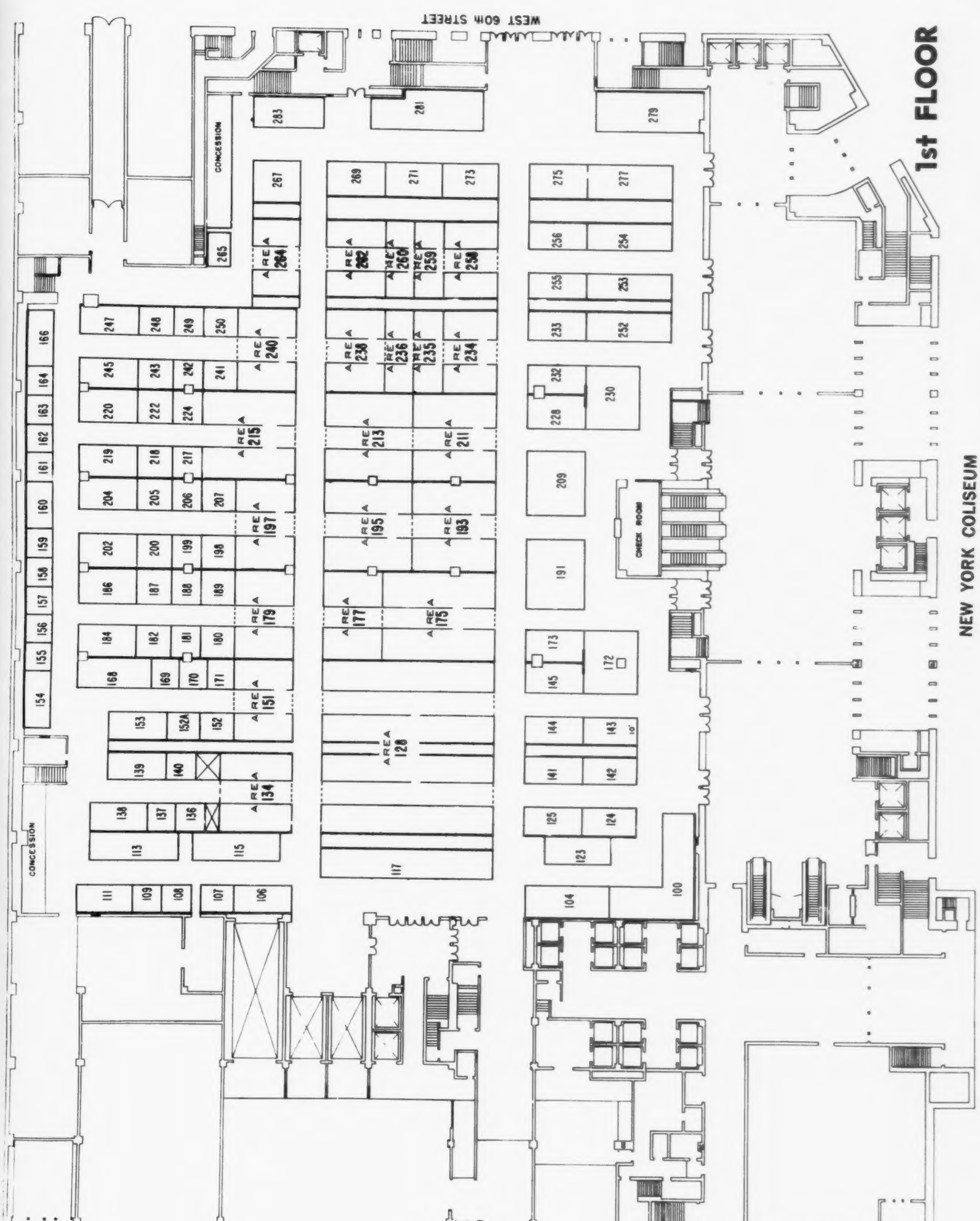
7
5
5
0
5
5

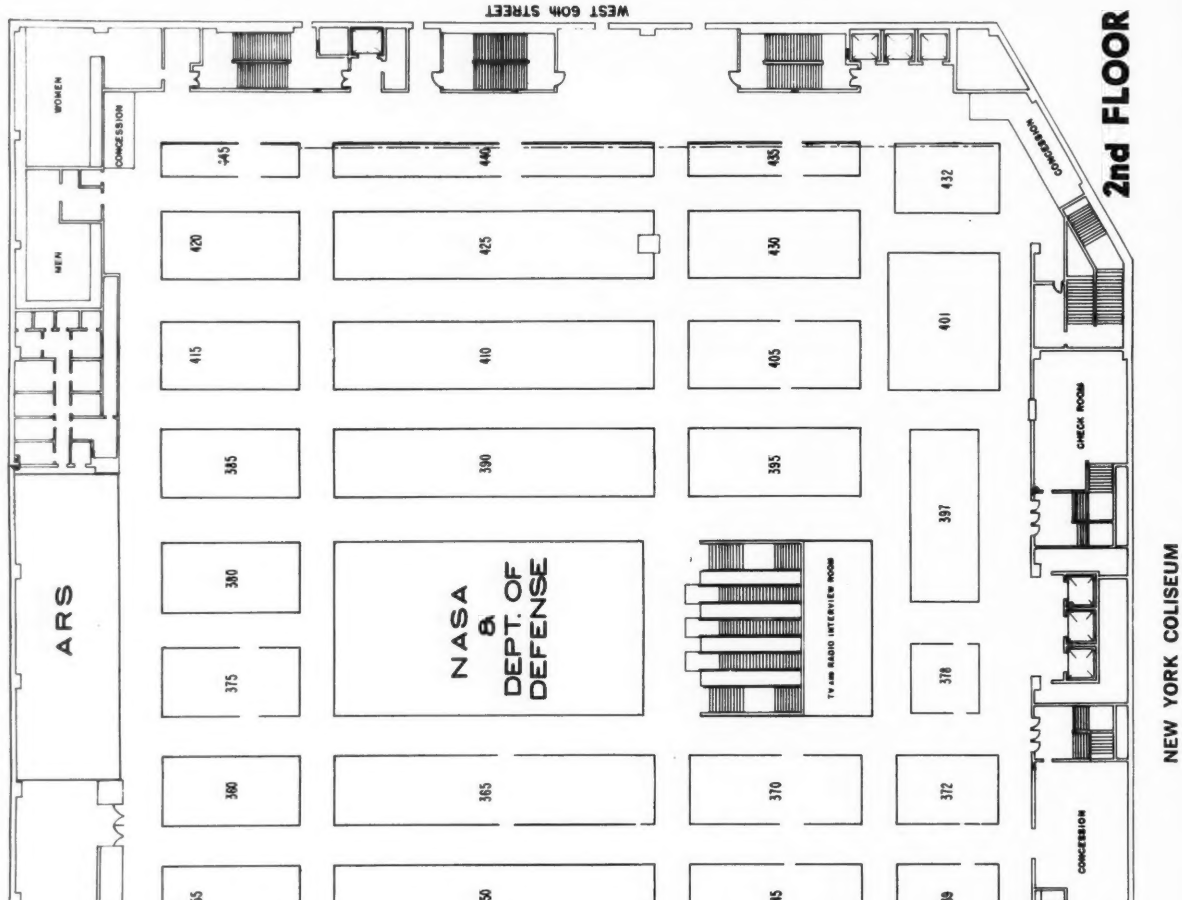
1
5
0
0
0
5
5

9
6
8
8
6
7
4
3
6
9
5
0
2
4

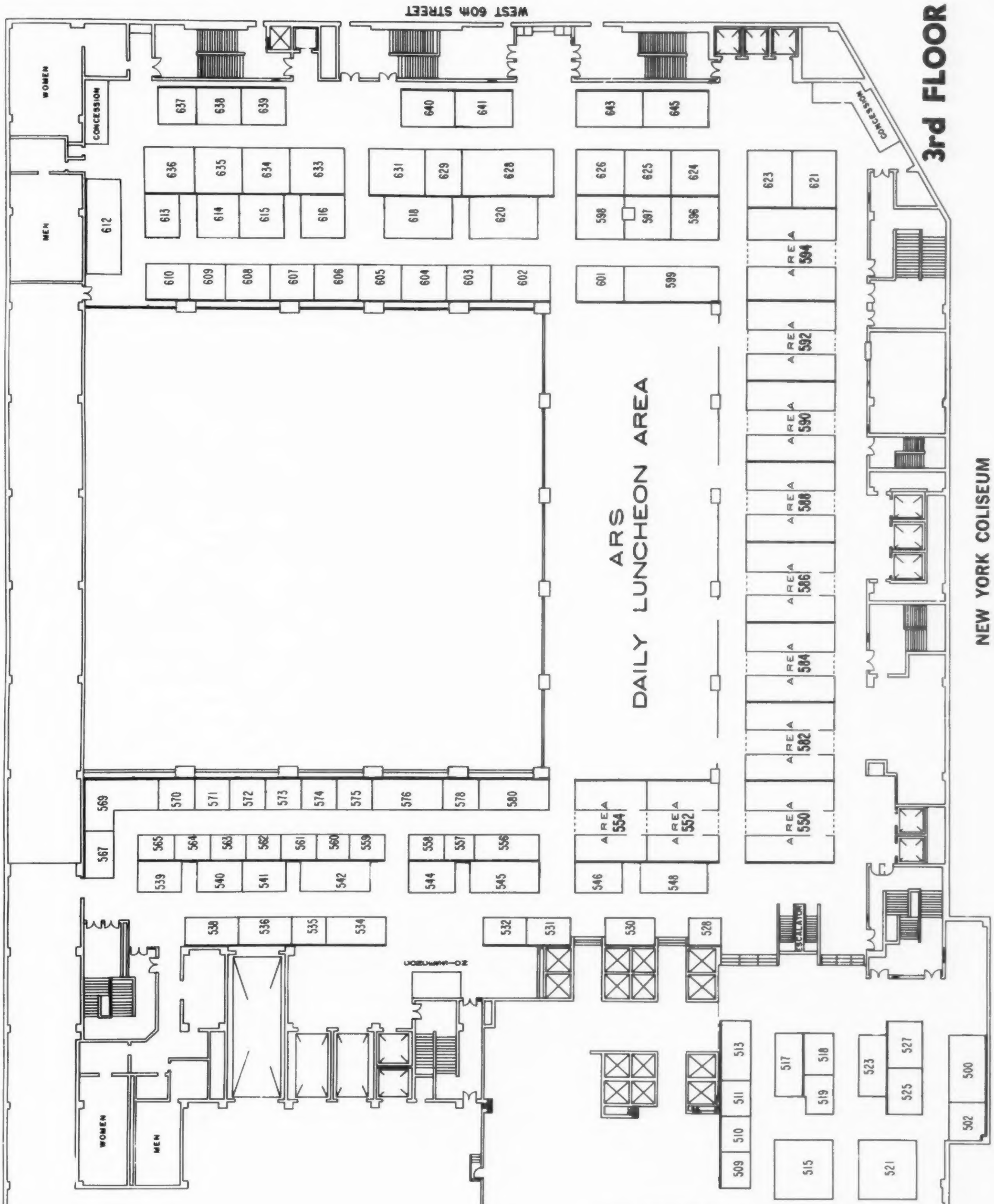
0
1
7
1
5
8
4
6
8
2
0
2
8
3
3
2

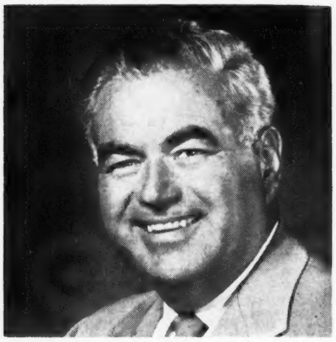
2
0
8
4


1st FLOOR
NEW YORK COLISEUM
WEST 60th STREET
WEST 58th STREET
CONCESSION
CHECK ROOM



WEST 60th STREET
2nd FLOOR
WOMEN
MEN
CONCESSION
345
440
435
432
420
425
430
401
415
410
405
385
390
395
397
CHECK ROOM
ARS
380
375
NASA & DEPT. OF DEFENSE
TV and RADIO INTERVIEW ROOM
378
NEW YORK COLISEUM
360
365
370
372
CONCESSION
355
350
345
339
325
330
335
337
317
315
310
305
300
CONCESSION
WOMEN
MEN
WEST 58th STREET


3rd FLOOR
NEW YORK COLISEUM
WEST 60th STREET
WEST 58th STREET
ARS
DAILY LUNCHEON AREA
CONCESSION
WOMEN
MEN
ESCALATOR



Arthur Kantrowitz
Chairman, ARS Public Education Committee

The SFRN public program

IN OPENING the doors of the New York Coliseum to the public during the week of the SPACE FLIGHT REPORT TO THE NATION, October 9–15, the American Rocket Society is giving the nonprofessional the first opportunity to get a close look at U.S. space vehicles, lunar and planetary probes, satellites, space capsules, and rocket boosters, all assembled in one place in what will be the largest exposition ever held devoted solely to astronautics and rocketry.

As Wernher von Braun, chairman of the ARS-SFRN Committee, points out in his article on page 66, ARS, although a professional society, recognizes an important obligation to communicate the significance of the field of astronautics to the public, which, in the final analysis, supports the U.S. space exploration program.

It was for this reason that ARS decided when SFRN was still in the planning stages to invite the public to the Astronautical Exposition, and also to provide a special series of public lectures in the evening, when the Exposition would be open to the nonprofessional.

Thus, on Monday evening, Oct. 9, laymen attending the meeting will be able to attend lectures and panel discussions on the evolution of American liquid-propellant rocket engines, education, electric propulsion, or astrodynamics, while on Tuesday evening they will have their choice of sessions on human factors, space law and sociology, technical information, or power systems.

One of the highlights of the public program is a special panel discussion on Thursday evening, Oct. 12, devoted to the topic: "The U.S. and USSR Space Programs: A Critical Evaluation."

As an added attraction, there will be public showings of films on space flight and rocketry supplied by NASA at specified hours every evening and on the weekend. The public is also invited to all of the sessions on Space Education Day, to be held Saturday, Oct. 14 (see page 83).

The SFRN public program was organized by the ARS Public Education Committee, headed by Arthur Kantrowitz of Avco Corp., in cooperation with the ARS Technical Committees.

Public attendance at SFRN is expected to be about 150,000, which would be one of the all-time highs at the New York Coliseum. ♦♦

PUBLIC LECTURE SERIES

Monday, October 9

7:00 p.m. — Room 4
The Evolution of American Liquid-Propellant Rocket Engines
(Discussion and films)

7:30 p.m. — Room 3
Continuing Education

7:30 p.m. — Room 5
Electric Propulsion
(Panel Discussion)

7:30 p.m. — Room 2
Astrodynamics
(Films and narration)

Tuesday, October 10

7:30 p.m. — Room 4
Human Factors
(Films and narration)

7:30 p.m. — Room 3
Space Law and Sociology

7:30 p.m. — Room 5
Technical Information—The Paper Curtain

7:30 p.m. — Room 2
Power Systems

Thursday, October 12

The U.S. and USSR Space Programs: A Critical Evaluation

7:30 p.m. — Rooms 3 and 4

Arthur C. Clarke
Past Chairman
British Interplanetary Society
Colombo, Ceylon

Lt. Gen. Bernard A. Schriever
Commander
Air Force Systems Command
Andrews Air Force Base, Md.

Hugh L. Dryden
Deputy Director
National Aeronautics & Space Administration
Washington, D. C.

Arthur Kantrowitz
Vice President
Avco Corporation, Everett, Mass.

F. J. Krieger
Physics Department
Rand Corporation, Santa Monica, Calif.

Wernher von Braun
Director
George C. Marshall Space Flight Center
National Aeronautics & Space Administration
Huntsville, Ala.

Exhibit Hours for the Public

Monday, Oct. 9, through Friday, Oct. 13	5 p.m. to 10 p.m.
Saturday, Oct. 14	10 a.m. to 10 p.m.
Sunday, Oct. 15	1 p.m. to 8 p.m.

Admission Fees
Adults: $1.50
Children under 16: $.75

SFRN Space Education Day

One of the highlights of the ARS SPACE FLIGHT REPORT TO THE NATION will be the all-day program on Saturday, October 14, devoted to space education. While ARS has had an Education Committee for the past four years, and education sessions have been part of many Society programs, Space Education Day marks the first occasion on which an entire day will be devoted to the subject, and also the first time the public will be invited to attend the sessions.

Space Education Day will get underway with a morning session devoted to the "Challenge of the Space Program to Education," chaired by Maurice J. Zucrow of Purdue Univ. Speakers at the session, designed to review the aims and accomplishments of the U.S. space program and the respective roles of science and engineering in the program, are Edward Welsh, executive secretary of the National Aeronautics and Space Council; C. Stark Draper, head of the MIT Department of Aeronautics and Astronautics; and Robert Jastrow, chief of NASA's Theoretical Div.

Following a luncheon, which will be addressed by Sen. Jacob K. Javits (R., N. Y.), there will be three afternoon sessions, covering three different aspects of the space-age education problem. One session chaired by Vincent S. Haneman Jr., ARS Youth Program Director and president, Haneman Associates, will be devoted to pre-college education; a second session, in the form of a panel discussion, will cover undergraduate education; and the third session, chaired by George W. Sutton of the GE Missile and Space Vehicle Dept., will be devoted to graduate education.

Both nonprofessionals and professionals are being invited to all Space Education Day sessions, and a large attendance, including a good many youngsters, is anticipated.

SFRN Education Day was organized by the ARS Education Committee, chaired by Ali B. Cambel of the Northwestern Univ. Gas Dynamics Laboratory. Dr. Zucrow headed the Special Education Day Committee which planned the program. ♦♦

Space Education Day—October 14

CHALLENGE OF THE SPACE PROGRAM TO EDUCATION

9:00 a.m. **Rooms 3 and 4**

Chairman: Maurice J. Zucrow, Purdue Univ., Lafayette, Ind.

- ♦Objectives and Accomplishments of the U.S. Space Program, Edward Welsh, National Aeronautics and Space Council, Washington, D.C.
- ♦Role of Engineering in Space Exploration, C. Stark Draper, Dept. of Aeronautics and Astronautics, MIT, Cambridge, Mass.
- ♦Role of Science in Space Exploration, Robert Jastrow, Theoretical Div., Institute of Space Studies, NASA Goddard Space Flight Center, New York, N.Y.

LUNCHEON ADDRESS

12:15 p.m. **Third Floor Luncheon Area**

The Honorable Jacob K. Javits

PRE-COLLEGE EDUCATION

2:00 p.m. **Room 3**

Chairman: Vincent S. Haneman, Jr., ARS Youth Program Director and President, Haneman Associates, Inc., Dallas, Tex.

- ♦Cooperation with Organized Youth Groups, Richard J. Gunkel, Missiles and Space Engineering Dept., Douglas Aircraft, Santa Monica, Calif.
- ♦Cooperation with Other Professional Societies in Support of Pre-College Education, Miss Mata Ellis, Aerojet-General, Sacramento, Calif.
- ♦Cooperation with Boards of Education and Direct Assistance to Teachers, Charles J. Migliazzo, Los Angeles City School District, Los Angeles, Calif.
- ♦Cooperation with Publishers, Authors, and Editors to Obtain Educational Material for Pre-College Students, J. Kendrick Noble Jr., Noble and Noble Publishers, New York, N.Y.
- ♦Cooperation with Secondary Schools, Career Planning, and Counseling, Samuel Shenburg, Board of Education, N.Y.C. Public Schools, New York, N.Y.

UNDERGRADUATE EDUCATION FOR THE SPACE FLIGHT ERA

(Panel)

2:00 p.m. **Room 5**

Chairman: Leo Steg, Missile and Space Vehicle Dept., General Electric Co., Philadelphia, Pa.

Paul Chenea, Vice-President, Academic Affairs, Purdue Univ., Lafayette, Ind.

Paul Sandorff, Dept. of Aeronautics and Astronautics, MIT, Cambridge, Mass.

Loren E. Morey, Technical Specialist, Chemical Propulsion, Hercules Powder Co., Magna, Utah

GRADUATE PROGRAM

2:00 p.m. **Room 2**

Chairman: George W. Sutton, Missiles and Space Vehicle Dept., General Electric Co., Philadelphia, Pa.

- ♦Graduate Education—The Problem of the University, R. L. Bisplinghoff, MIT, Cambridge, Mass.
- ♦Graduate Education—Government's Needs, Lawrence Kavanau, Dept. of Defense, Washington, D.C.
- ♦Graduate Education—Industrial Needs, Richard Horner, Northrop Corp., Beverly Hills, Calif.

Ali B. Cambel
Chairman, ARS Education Committee

Maurice J. Zucrow
Chairman, Education Day Committee

Educational programs in astronautics

New ARS survey indicates that many university and college curricula now include the various astronautical disciplines, with emphasis shifting from handbook courses to study of basic physical concepts

By John A. Thornton, SECRETARY, ARS EDUCATION COMMITTEE
and Ali Bulent Cambel, CHAIRMAN, ARS EDUCATION COMMITTEE

Thornton Cambel

John Thornton is now a senior doctoral candidate in Northwestern Univ.'s Gas Dynamics Laboratory. Holder of B.S. and M.S. degrees from the Univ. of Washington, he is chairman of the Aviation Professional Div. of the Chicago Section of ASME and president of the Northwestern Gas Dynamics Colloquium, as well as secretary of the ARS Education Committee.

Ali Cambel is Walter P. Murphy professor of mechanical engineering and chairman of the Mechanical Engineering Dept. at Northwestern, as well as director of the university's Gas Dynamics Laboratory. An internationally known educator, he is a Fellow and National Director of ARS and is a past chairman of the MHD Technical Committee of the Society. He has also been elected a National Lecturer of Sigma Xi.

In the history of man, there are a number of discoveries and accomplishments which have altered the destiny of the human race. There seems little doubt that the conquest of space will be one of these profound forces influencing the trend of events. Indeed, when historians write the story of the 20th century, they will most likely credit it with two characteristics. One of these will be the awakening of compassion among men for their fellow human beings, and the other will be the entrance of man into space and onto other planets. Historians will probably note further that the conquest of space differed from previous revolutionary human achievements in that it required an unusually sophisticated background in education. It is the purpose of this annual review to peruse American educational trends and objectives for the space age.

Several decades ago it was possible to differentiate between "science" and "technology" because as a rule science led the way by many, many years. Furthermore, science was generally pursued to satisfy intellectual curiosity whereas technology was developed to produce a certain piece of hardware. Today the line of demarcation between "science" and "technology" has become almost imperceptible. In fact, the impetus for much modern scientific research is found in the need to build up underlying knowledge in order to create certain technologies. Thus, the engineer today follows closely on the heels of the scientist and at times becomes a scientist himself. This close alliance is demonstrated in the successful companies, which maintain large research departments because without research modern technology would become sterile and would disappear quickly.

Schools, too, have had to change their curricula, and are continuing to do so daily. The principal change has been to minimize, and even to delete, skill or handbook courses and to emphasize instead a profound understanding of fundamental physical concepts coupled with an appreciation for mathematical dexterity. The reason for this change is that the rapid advances in science and technology make obsolete the skills and the information contained in handbooks. The modern scientist-engineer can continue to contribute to his profession only if he knows thoroughly the implications of the laws of nature. Knowing these, he can constantly meet the challenge of developing heretofore unknown devices and processes. One might observe that the discoverers and

designers of new laws or devices rarely had studied in school what they conceived!

The young man or woman who decides to enter the field of astronautics should therefore plan his or her education very carefully. During the undergraduate years, emphasis should be placed on receiving as broad and as rigorous an education as possible, with little if any specialization. The choice of a school is a difficult process even for those in the academic field because the reputation of a school can linger on long after the school has lost its most inspiring faculty members. (We cannot stress too much that it is not massive buildings or even impressive course titles which make a school great, but the quality of its faculty.)

The student should then seek to learn mathematics at least through vector and tensor analysis; physics through modern physics; and chemistry through reaction kinetics. Among the engineering courses, the undergraduate student would do well to study electricity through field theory and electronics; thermodynamics through statistical mechanics; fluid mechanics through compressible flow and transport phenomena; mechanics through continuum theory; and materials through solid-state physics. He should then study astrodynamics and should be initiated into astrophysics. Finally, he should study in the biological sciences.

A person following such a program will not be a specialist in astronautics but will have obtained a body of knowledge which would enable him to speak intelligently about events happening in the space age. He will also be ready to embark on a career in graduate school leading to the Ph.D. or Sc.D. degree.

The student who is interested in the field of astronautics should give serious consideration to graduate study. The increasing complexity of the space sciences is more and more making graduate study a prerequisite for work on the interesting and stimulating projects. This trend is illustrated in the graph on page 87, which shows the increase in doctorate degrees granted in science and engineering over the years.

Balance Needed Intellectually

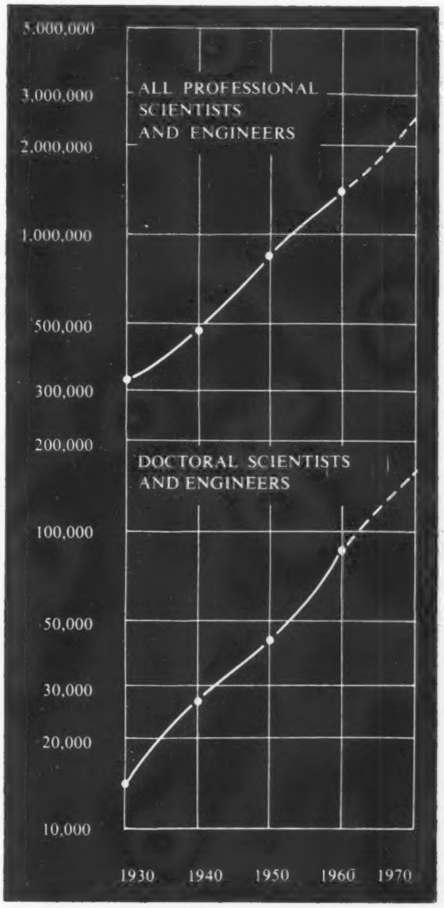
In graduate school, the student should continue to maintain his wide intellectual scope. However, this is also the period of specialization. Thus, after the great philosopher-mathematician Alfred North Whitehead, we might suggest that the scientist-engineer in the space age should be good in everything and excellent in at least one field.

The multifarious areas of specialization in rocketry and astronautics are represented by the 19 Technical Committees of the American Rocket Society, whose functions are described in the table on page 86. In order to make an assessment of the educational opportunities available, an informal survey was conducted in which colleges and universities were requested to list their course offerings and/or current research in each of the disciplines covered by the Technical Committees. The replies are summarized in the table on pages 88-89. (Only those returns which indicated some activity in the 19 committee areas have been included in the summary.) We wish to caution the reader that the table is only representative, since a number of fine and well-known schools did not respond to the survey.

It is impossible to list schools in order of excellence, for excel-

Scientists and Engineers in the Labor Force, 1930–1970

(National Science Foundation)



lence does not necessarily endure and no one school can be excellent in everything—nor could any appraisal based on this scheme take full account of the key ingredient, a fine faculty. Indeed, rating the various schools on the excellence of their academic programs was not the objective of this survey and would be inconsistent with ARS policies. Accordingly, we would discourage any attempt to rank the strengths of the various programs merely by counting the number of entries in the table. For example, it would be conceivable for a school to have one graduate survey course which touched briefly on all of the 19 technical disciplines. This school might then appear stronger than one with an outstanding program in a few of the areas of study. Thus the prospective student is urged to send for catalogs from all the institutions which appear to have offerings in his areas of interest. For details on the college research programs the reader is referred to the "Engineering College Research Review," which is published biennially by the Engineering College Research Council of the American Society for Engineering Education. (Copies of this publication may be ordered from the American

ARS TECHNICAL COMMITTEES AND SCOPES

ASTRODYNAMICS

Motion of bodies outside the material atmosphere of the earth; prediction, observation, analysis of forces and energy required to modify such motion, particularly as required by activities remote from the extraterrestrial body itself.

COMMUNICATIONS AND INSTRUMENTATION

Data or instructions portraying or adjusting the internal functioning and external environment of missile and space vehicle equipment; sensing, transmission, and processing of such information, e.g., by electromagnetic means.

ELECTRIC PROPULSION

Application of electrical, electromagnetic, electrostatic, or electrothermal means to the propulsion of missiles or space vehicles; the technology of equipment resulting from such application.

GUIDANCE AND CONTROL

The theoretical and practical considerations of techniques, devices, and systems for the guidance and attitude control of missiles and space vehicles.

HUMAN FACTORS AND BIOASTRONAUTICS

Elements of technology related to the participation of man or other living organisms in missile and space systems, particularly studies of man's relation to the resulting environment and of his capabilities for participation in system functions and command thereof.

HYPERSONICS

Motion of bodies within the material atmosphere of the earth or other celestial bodies and the physics of related phenomena, particularly at substantial multiples of the local speed of sound.

LIQUID ROCKETS

Application of mechanical design, fluid mechanics, and thermochemistry to the propulsion of missiles or space vehicles, particularly employing liquid propellant; the technology of equipment resulting from such application.

MAGNETOHYDRODYNAMICS

Physics of plasmas and other streams wherein electrical or electromagnetic phenomena are of significance comparable to or greater than inertial, viscous, or convective phenomena.

MISSILES AND SPACE VEHICLES

Application of technology to the planning, design, fabrication, and operation of complete missiles and space vehicles, particularly technical management of such vehicles and the weapon or exploration systems of which they are components.

NUCLEAR PROPULSION

Application of fluid mechanics and nuclear energy to the propulsion of missiles or space vehicles. Also the physics of nuclear energy provision for missiles and space vehicles.

PHYSICS OF THE ATMOSPHERE AND SPACE

Physics of the atmospheres of the various celestial bodies and of the matter and fields existing in space, particularly observational physics made possible by sounding rockets, interplanetary probes, and space vehicles; the technology of instruments used in such observational physics.

POWER SYSTEMS

Application of science and technology in the provision of power to missiles and space vehicles. Includes physical systems and components employed to support or modify the internal capabilities and environments of missiles and space vehicles, as by heat rejection, but does not include systems or components used in propulsion.

PROPELLANTS AND COMBUSTION

Physics and chemistry of reactants and working fluids suitable for missile or space-vehicle propulsion, including chemical, physical, and aerothermodynamic processes and properties by means of which energy is made available in conformity with engine design requirements.

RAMJETS

Application of fluid mechanics, thermochemical technology, and mechanical design to the propulsion of missiles or space vehicles using surrounding gaseous or particulate matter as a reactant and/or a working fluid.

SOLID PROPELLANT ROCKETS

The application of fluid dynamics, heat transfer, structural integrity, materials technology, and fabrication and processing techniques to solid-propellant rocket-motor design.

SPACE LAW AND SOCIOLOGY

Application of the juridical and sociological branches of the social sciences and extension of these sciences themselves in the field of astronautics, as for example, development of regulations for the use of radio, the safety of life and property in outer space, the preparation of human society for exploration and use of outer space.

STRUCTURES AND MATERIALS

Application of the technologies of structures and materials to the solution of missile and space-vehicle design, fabrication and operation problems; also extension of these technologies for more effective integration of structures and materials in these applications.

TEST, OPERATIONS, AND SUPPORT

Application of technology to the planning, design, installation, and operation of facilities and ranges for the testing and operational support of missiles, space vehicles, and major subsystems thereof; also the application of technology to the operation-support activities themselves.

UNDERWATER PROPULSION

Application of fluid mechanics and of other energy-conversion technology to the propulsion of vehicles operating in liquid media, such as water.

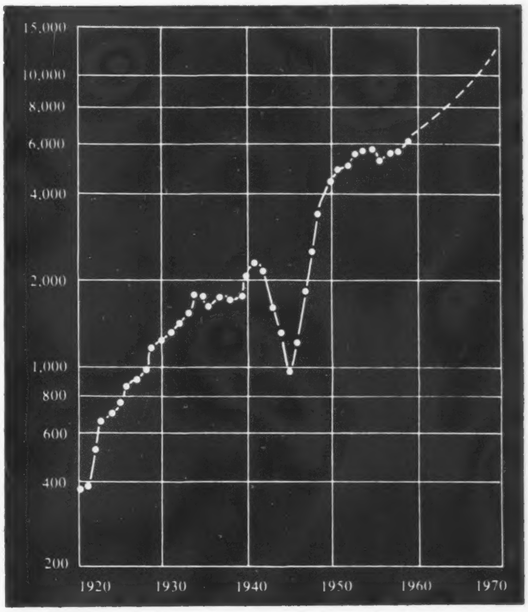
Society for Engineering Education, Univ. of Illinois, Urbana, Ill.)

By and large, *all* accredited schools provide adequate educational programs. (A list of the accredited curricula leading to first degrees in engineering in the United States may be obtained from the American Society for Engineering Education.) One need not think that the most capable scientists come only from the most famous schools, because they do not. The so-called great schools do not assure excellence; they can only assure higher than average minimal competence. Although the choice of schools on the undergraduate level is numerous, on the graduate level there are fewer schools which provide advanced instruction. In turn, among the schools providing graduate instruction, those that offer the doctorate degree are fewer than those offering the master's degree.

A special program that prospective astronautical engineers should understand is the cooperative or "co-op" plan of engineering education, now offered by many schools. (A list of such co-op programs can be obtained by obtaining the booklet "List of Cooperative Educational Programs" from the Examining Div., U.S. Civil Service, Washington, D.C.) Under this program, the student alternates between school and an industrial job each quarter or se-

Doctorates in Science and Engineering, 1920–1970

(National Science Foundation)



ARS STUDENT CHAPTERS

Academy of Aeronautics
La Guardia Airport
Flushing, N.Y.

Alabama Polytechnic Institute
Auburn, Ala.

Boston Univ.
Boston, Mass.

California State Polytechnic Institute
San Luis Obispo, Calif.

Univ. of California
Berkeley, Calif.

City College of New York
New York, N.Y.

Univ. of Colorado
Boulder, Colo.

Univ. of Connecticut
Storrs, Conn.

Drexel Institute of Technology
Philadelphia, Pa.

Fairleigh Dickinson Univ.
Teaneck, N.J.

Fenn College
Cleveland, Ohio

Univ. of Florida
Gainesville, Fla.

Georgia Institute of Technology
Atlanta, Ga.

Univ. of Hartford
Hartford, Conn.

Univ. of Louisville
Louisville, Ky.

Manhattan College
Riverdale, N.Y.

Marquette Univ.
Milwaukee, Wis.

Massachusetts Institute of Technology
Cambridge, Mass.

Univ. of Miami
Coral Gables, Fla.

Univ. of Michigan
Ann Arbor, Mich.

Univ. of Minnesota
Minneapolis, Minn.

Univ. of Missouri
Columbia, Mo.

Missouri School of Mines
& Metallurgy
Rolla, Mo.

Newark College of Engineering
Newark, N.J.

New York Univ.
New York, N.Y.

Univ. of Notre Dame
Notre Dame, Ind.

Univ. of Oklahoma
Norman, Okla.

Parks College
East Saint Louis, Ill.

Univ. of Pittsburgh
Pittsburgh, Pa.

Polytechnic Institute of Brooklyn
Brooklyn, N.Y.

Rensselaer Polytechnic Institute
Troy, N.Y.

Saint Ambrose College
Davenport, Iowa

Stevens Institute of Technology
Hoboken, N.J.

Univ. of Texas
Austin, Tex.

Tri-State College
Angola, Ind.

U.S. Naval Postgraduate School
Monterey, Calif.

Vanderbilt Univ.
Nashville, Tenn.

Univ. of Virginia
Charlottesville, Va.

Univ. of Washington
Seattle, Wash.

Wayne State Univ.
Detroit, Mich.

mester. The advantage or disadvantage of choosing a "co-op" education depends, of course, on one's professional plans.

Admission requirements vary from school to school, but the College Board Scholastic Aptitude Test is recommended, if not required, by most. High school counselors can provide information about this test, or descriptive booklets may be ordered from the College Entrance Examination Board, c/o Educational Testing Service, Box 592, Princeton, N.J., or Box 27896, Los Angeles 27, Calif. Admission to graduate school is primarily based on the undergraduate record, but, if an applicant attended an unaccredited school or feels that his record does not show his true abilities, the Graduate Record Examination is recommended, or sometimes required. Information about this exam may also be obtained from Educational Testing Service.

A wide variety of financial aid is available to both undergraduates and graduates in any field of space science. Individual colleges and universities can provide detailed information upon request, both in general catalogs and separate brochures. A summary of financial aid for graduate study in engineering is published by the Tau Beta Pi Association. ("A Compilation of Financial Aid for Graduate Study in Engineering," *The Council Bulletin of the Tau Beta Pi Association,* published by the George Banta Co., Inc., Curtis Reed Plaza, Menasha, Wis.)

The student should remember that his college and postgraduate years constitute a tremendous invest-

SURVEY OF COURSES AND RESEARCH IN ASTRONAUTICS

THE FIRST COLUMN UNDER EACH TECHNICAL DISCIPLINE, LABELED "C", REFERS TO AVAILABLE COURSES. THE SECOND COLUMN, LABELED "R", REFERS TO RESEARCH IN PROGRESS. THE STAR DESIGNATION ☆ IN THE C-COLUMN INDICATES COURSES FOR SENIOR UNDERGRADUATE AND GRADUATE STUDENTS, WHILE THE SOLID DESIGNATION ■ INDICATES COURSES PRIMARILY FOR GRADUATE STUDENTS. THE "X" DESIGNATION INDICATES COURSES TO BE OFFERED IN THE NEAR FUTURE.

ARS TECHNICAL COMMITTEE DISCIPLINES

	Astrodyn.		Comm. & Instr.		Elec. Prop.		Guid. & Control		Human Factors		Hyper-sonics		Liquid Rockets		MHD		Missiles & Space Vehicles	
	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R
ARIZONA																		
UNIV. OF ARIZONA	■	■	☆	■	■		■	■			■	■	■		■		■	
CALIFORNIA																		
CALIF. INST. OF TECH.	■				■	■					■	■	■	■	■	■	■	
STANFORD UNIV.	■	■	■	■	■		■	■			■	■	■		■	■	■	
UNIV. OF CALIF.											■	■	■	■	■	■		
UNIV. OF CALIF. AT LOS ANGELES	■		■	■	☆		■	■	■		■	■	☆		■			
UNIV. OF SO. CALIFORNIA	■				■				■		■		■		■			
COLORADO																		
UNIV. OF COLORADO	■		■				■	■	■	■	■		☆		■		☆	
CONNECTICUT																		
YALE UNIV.			■								■	■						
FLORIDA																		
UNIV. OF FLORIDA	■		■	■	■		■	■		■	■	■	☆		■	■		
GEORGIA																		
GEORGIA INST. OF TECH.	■	■	■	■			☆	■			■		■	■	■	■	☆	
ILLINOIS																		
ILLINOIS INST. OF TECH.	■				■	■	■	■			■				■	■		
NORTHWESTERN UNIV.	■	■	■		☆	■	■	■			■	■	☆		■	■		
UNIV. OF ILLINOIS	■	■	■	■	■	■	■	■	■		■	■	☆	■	■	■	☆	
INDIANA																		
PURDUE UNIV.					■	■	☆				☆	■	■	■	■	■	☆	
ROSE POLY. INST.	☆	■																
UNIV. OF NOTRE DAME	☆						■				■		☆		■		☆	
IOWA																		
IOWA STATE UNIV.	■	■	■	■	☆		■	■			■	■	☆		■			
KANSAS																		
KANSAS STATE UNIV.		■	■	■			☆	■		■	■		☆		■	■		
UNIV. OF KANSAS			☆								☆		☆				☆	
MARYLAND																		
JOHNS HOPKINS UNIV.			■	■											■	■		
UNIV. OF MARYLAND			■	■			■				■	■				■		■
MASSACHUSETTS																		
HARVARD UNIV.	■	■	■			■	■	■	■		■				■	■		
MASS. INST. OF TECH.	■	■	■	■	■	■	■	■	☆	■	■	■	■		■	■	■	■
TUFTS UNIV.			☆						■	■								
WORCESTER POLY. INST.	■										■		☆					
MICHIGAN																		
MICHIGAN STATE UNIV.	■	■					■	■			■				■	■		
UNIV. OF DETROIT	■												■				☆	
UNIV. OF MICHIGAN	■	■	■	■			■	■		■	■	■	☆		■	■	■	■
WAYNE STATE UNIV.	■				☆	■	☆	■		■					■	■	☆	
MINNESOTA																		
UNIV. OF MINNESOTA	■	■		■	■		■				■		■	■	■	■	■	
MISSISSIPPI																		
MISSISSIPPI STATE UNIV.										■								

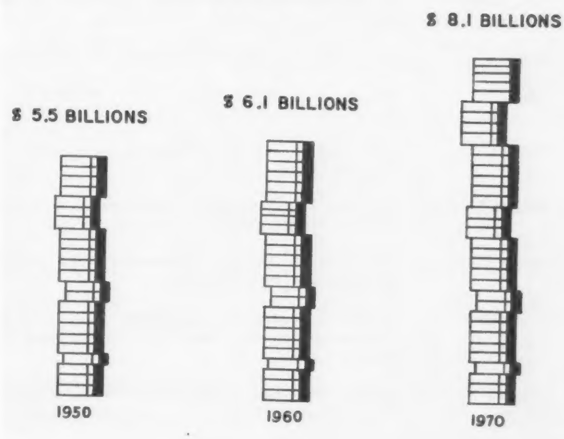
	Nuclear Prop.		Phys. of Atm. & Space		Power Systems		Prop. & Comb.		Ramjets		Solid Rockets		Space Law		Structures & Mat'ls.		Test Op'ns. & Support		Under-water Prop.	
	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R
ARIZONA																				
UNIV. OF ARIZONA	■				☆	■	■	■	■		■				☆	■				
CALIFORNIA																				
CALIF. INST. OF TECH.	■		■	■	■		■	■	■		■	■			■	■				
STANFORD UNIV.	■		■	■			■		■		■				■	■				
UNIV. OF CALIF.			■	■			■	■							■	■				
UNIV. OF CALIF. AT LOS ANGELES	■		■				■		☆		☆	■			■	■				
UNIV. OF SO. CALIFORNIA							■		■		■				☆					
COLORADO																				
UNIV. OF COLORADO	■		■		☆		☆		☆		☆		■		■					
CONNECTICUT																				
YALE UNIV.				■				■												
FLORIDA																				
UNIV. OF FLORIDA	■	■	☆				☆		☆		☆	■			☆					
GEORGIA																				
GEORGIA INST. OF TECH.	■	■		■			■		■		■				■	■				
ILLINOIS																				
ILLINOIS INST. OF TECH.	■		☆		■	■	■	■	■	■					■	■			■	■
NORTHWESTERN UNIV.	☆		☆	■			■	■	☆		☆				■	■				
UNIV. OF ILLINOIS	■		■				■	■	☆	■	☆	■			■	■				■
INDIANA																				
PURDUE UNIV.	■	■			☆		☆	■	■		■	■			■	■				
ROSE POLY. INST.																				
UNIV. OF NOTRE DAME							☆		☆		☆									
IOWA																				
IOWA STATE UNIV.	■	■	☆				☆		☆		■	■			■	■	☆			
KANSAS																				
KANSAS STATE UNIV.							☆		☆		☆					■				
UNIV. OF KANSAS									☆		☆				☆					
MARYLAND																				
JOHNS HOPKINS UNIV.																				
UNIV. OF MARYLAND				■		■	■		■		■				■	■				■
MASSACHUSETTS																				
HARVARD UNIV.							■	■								■				
MASS. INST. OF TECH.	■	■	■	■	■	■	■	■	☆			■			■	■				
TUFTS UNIV.							☆													
WORCESTER POLY. INST.							☆	■	☆											
MICHIGAN																				
MICHIGAN STATE UNIV.	☆																			
UNIV. OF DETROIT																				
UNIV. OF MICHIGAN	■		■	■			■	■	☆		☆		■		■	■				
WAYNE STATE UNIV.																				
MINNESOTA																				
UNIV. OF MINNESOTA	■		■		☆		■	■	☆		■	■			■	■				■
MISSISSIPPI																				
MISSISSIPPI STATE UNIV.																				

	Astrodyn.		Comm. & Instr.		Elec. Prop.		Guid. & Control		Human Factors		Hypersonics		Liquid Rockets		MHD		Missiles & Space Vehicles		Nuclear Prop.		Phys. of Atm. & Space		Power Systems		Prop. & Comb.		Ramjets		Solid Rockets		Space Law		Structures & Mat'ls		Test Op'ns & Support		Under-water Prop.	
	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R
MONTANA																																						
MONTANA STATE COLLEGE											☆																											
NEW JERSEY																																						
PRINCETON UNIV.	■		■	■	■		■	■			■	■	■	■	■	■			■		■				■	■	■		■	■			■					
STEVENS INST. OF TECH.	☆		■			■					■					■	☆		☆						☆								■				■	■
NEW YORK																																						
BROOKLYN POLY. INST.	■	■	■	■	■	■	■	■			■	■	☆	■	■	■					■	■					☆	■	☆	■			■	■				
COLUMBIA UNIV.			■	■	☆		■	■			■		☆		■	■			■						■		☆		☆				■	■				
CORNELL UNIV.	■	■	■		■		■				■				■	■					■				■	■												
NEW YORK UNIV.	■		■	■			■	■			■		■		■	■						■					■		■					■				
RENSSELAER POLY. INST.	■						■	■			■	■		■	■	■			■	■	■	■			■	■	■	■										■
OHIO																																						
CASE INST. OF TECH.	■	■	■		■	■	■		■	■	■	■	■	■	■	■			■	■	■				■		■		■				■	■				
OHIO STATE UNIV.	☆		■	■			■	■	■	■	☆	■	☆		■	■	☆				■	■	■		☆	■	☆		☆	■			☆	■				
UNIV. OF CINCINNATI	■	■	■		■	■	■	■	X		■	■	■	■	X	■	X	■	■	■	■		■		■		■	■	■	■			■		X			
OKLAHOMA																																						
OKLAHOMA STATE UNIV.	■	■	■	■			■		■		■	■		■							■	■	■	■			■			■								
UNIVERSITY OF OKLAHOMA	■	■			■	■	■				■	■	■		■	■	■		■		■	■			■		■	■	■				■					
OREGON																																						
OREGON STATE UNIV.	☆								☆	■						■																	■	■				
PENNSYLVANIA																																						
PENN. STATE UNIV.	☆		■	■	■	■	■		☆	■	■		■	■	■	■	☆		■		■	■			■	■	■		■				■	■				■
UNIV. OF PENNSYLVANIA	☆		■		■	■	■		■		■	■			■			■			☆												■					
SOUTH CAROLINA																																						
CLEMSON COLLEGE												■	■												■		■											
UNIV. OF SOUTH CAROLINA					X						■				X				X						X		X		X				☆					
UTAH																																						
UNIV. OF UTAH	☆		☆				■				☆		☆						☆		☆	■			☆		☆		☆									
UTAH STATE UNIV.			■	■			■				☆														☆				☆				☆			■		
VERMONT																																						
UNIV. OF VERMONT																																		■				
VIRGINIA																																						
VIRGINIA POLY. INST.	■				■		■	■			■	■	■	■	■		■		■	■					■				■				■					
UNIV. OF VIRGINIA	■	■	■				■	■			■	■	■		■							■			■	■	■		☆				■					
WASHINGTON																																						
UNIV. OF WASHINGTON	☆						■				■	■	☆								■												■	■				
WEST VIRGINIA																																						
WEST VIRGINIA UNIV.	■						☆						☆				☆										☆						■	■				
WISCONSIN																																						
UNIV. OF WISCONSIN			■		■									■		■										■												
WYOMING																																						
UNIV. OF WYOMING													■												■		■		■									
CANADA																																						
ONTARIO																																						
UNIV. OF TORONTO	■		☆		■	■	■	■			■	■	■		■				■		■	■					■		■				■					
QUEBEC																																						
McGILL UNIV.											■	■																										

ment, and care should be exercised in choosing a school. One should differentiate, for example, between non-academic research laboratories operated by schools and academic research laboratories. The student will find the greatest opportunity to do research in the academic laboratories of schools.

As has been noted, the emphasis should be on fundamentals. It will be seen from the table mentioned that most of the specific courses in the aeronautical and astronautical sciences are taught at the graduate level. Thus, the prospective student should not feel compelled to attend an undergraduate school where such courses are available. The ARS Student Chapter program has proven very effective in keeping undergraduate students abreast of developments in astronautics at a time when they are concentrating on the more fundamental subjects. A list of ARS Student Chapters will be found on page 87. (CONTINUED ON PAGE 134)

Research and Development Expenditures, 1950–1970



On the calendar

1961	
Oct. 2–4	Seventh National Communications Symposium of IRE Professional Group on Communications Systems, Hotel Utica and Municipal Auditorium, Utica, N.Y.
Oct. 2–7	**XIIth International Astronautical Congress, Washington, D.C.**
Oct. 4–6	American Society of Photogrammetry Semi-Annual Convention, Biltmore Hotel, New York, N.Y.
Oct. 9–11	National Electronics Conference sponsored by IRE, AIEE, et. al., International Amphitheatre, Chicago, Ill.
Oct. 9–15	**ARS SPACE FLIGHT REPORT TO THE NATION, New York Coliseum, New York, N.Y.**
Oct. 10–13	Annual Meeting of the Wissenschaftliche Gesellschaft fur Luftfahrt, Freiburg im Breisgau, Germany.
Oct. 23–25	International Scientific Radio Union Fall Meeting, Univ. of Texas, Austin, Tex.
Oct. 23–26	Symposium on Aerospace Nuclear Propulsion, Hotel Riviera, sponsored by IRE, AEC, and NASA, Las Vegas, Nev.
Nov. 1–3	AFOSR International Conference on High Magnetic Fields, Massachusetts Institute of Technology, Cambridge, Mass.
Nov. 7–10	American Nuclear Society Hot Laboratory and Equipment Conference, Chicago, Ill.
Nov. 12–17	Conference on Medical and Biological Problems in Space Flight, Nassau, Bahamas.
Nov. 14–16	AFOSR International Conference on the Exploding Wire Phenomenon, Boston, Mass.
Nov. 30–Dec. 1	IRE Professional Group on Vehicular Communications Conference, Hotel Leamington, Minneapolis, Minn.
Dec. 3–7	AIChE Annual Meeting, Hotel Commodore, New York, N.Y.
Dec. 26–31	Annual National Meeting of the American Assn. for the Advancement of Science, Denver, Colo.
1962	
Jan. 9–11	National Symposium on Reliability and Quality Control sponsored by IRE, AIEE, et. al., Statler-Hilton Hotel, Washington, D.C.
Jan. 24–26	ASME Thermophysical Properties Symposium, Princeton Univ., Princeton, N.J.
Jan. 24–26	**ARS Solid Propellant Rocket Conference, Baylor Univ., Waco, Tex.**
Feb. 4–7	AIChE National Meeting, Statler-Hilton, Los Angeles, Calif.
Feb. 7–9	IRE National Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Calif.
Feb. 19	IAS Tracking and Surveillance of Aerospace Vehicles Meeting, San Francisco, Calif.
March 14–16	**ARS Electric Propulsion Conference, U.S. Naval Postgraduate School, Monterey, Calif.**
April 3–5	**ARS Launch Vehicles Structures and Materials Conference, Ramada Inn, Phoenix, Ariz.**
April 10–12	AFCRL Symposium on the Plasma Sheath—Its Effect Upon Re-entry Communication and Detection, New England Mutual Hall, Boston, Mass.
June 13–15	Annual Heat Transfer and Fluid Mechanics Institute, Univ. of Washington, Seattle, Wash.

Space Flight and the Man

(CONTINUED FROM PAGE 63)

expressed, is the following passage from Prof. Lewis Mumford's "The Transformation of Man."

> "Post-historic man's starvation of life would reach its culminating point in interplanetary travel . . . Under such conditions, life would again narrow down to the physiological functions of breathing, eating, and excretion . . . By comparison, the Egyptian cult of the dead was overflowing with vitality; from a mummy in his tomb one can still gather more of the attribute of a full human being than from a spaceman."

The almost laughable falsehood of this passage was demonstrated by astronaut Shepard's famous exclamation "What a beautiful sight!" as his Mercury capsule arced over the Caribbean. I would maintain that these words are enough to settle the matter, but it must be admitted that most people would prefer more substantial evidence for the benefits of manned space flight.

Let me first dispose of one argument for man in space that is frequently put forward, and which only confuses the issue. It is often suggested that the complexity and unreliability of automatic space probes will make it impossible to dispense with human astronauts, even if they merely serve as troubleshooters. This is a short-sighted view: In the not-too-distant future—perhaps only 50 years from now—we will have robots as good as any flesh-and-blood explorers. The frequent and predictable failures of the next decade's automatic astronauts must not blind us to the fact that they will be only clumsy, moronic toys compared with their successors half a century hence. The justification of man in space must depend not upon the deficiencies of his machines, but upon the positive advantages that he, personally, will gain from going there.

There is no point in exploring—still less colonizing—a hostile and dangerous environment unless it opens up new opportunities for experience and spiritual enrichment. Mere survival is not sufficient; there are already enough examples on this planet of societies that have been beaten down to subsistence level by the forces of nature. The questions which all protagonists of space flight have to ask themselves, and answer to their own satisfaction, are these: What can the other planets offer that we cannot find here on earth? Can we do better on Mars or Venus than the Eskimos have done in the Arctic? And the Eskimos, it is worth reminding ourselves, have done very well indeed. A dispassionate observer might reasonably decide that

Kodak reports on:

Ektaline, sweet Ektaline . . . f/1 lenses for 4.25μ to 10μ . . . the pencil that enrages the mind

THIS paper

"My husband sells oscillograph paper. Competition is fierce. He comes home beat every night."

Few overhearing her would know what the poor soul is talking about, yet she speaks the truth. Oscillographs probably outnumber pickle barrels in this country at the present time. Oscillographers are correspondingly numerous. Methods that one sect of oscillographers prefers above all else another sect can't see for dirt. One sect prefers automatic oscillogram processors. Paper manufacturers like us find their favor worth competing for. Therefore we announce a new advance in media for their use.

An advance in the old art of papermaking came first. Then new emulsions were devised to work properly with the new base. Then proper processing chemicals were devised for the new emulsions. Then the combination was extensively proved out under practical conditions of use by parties interested only in end results and hardly at all in the how and why. They found that

1. THIS paper dries thoroughly at high processor speeds *without creases.* **180 in./min. is not too fast.**

2. THIS paper gives trace lines that stand out as black as the ace of spades. **Background is nice and clean.**

3. THIS paper isn't fussy about how long it sits around before use. **O.K. to keep plenty on hand.**

4. THIS paper is rugged. **No cracking, no crumbling.**

5. THIS paper holds its dimensions. **Justifies careful measurement.**

"THIS" won't do for a trademark. (The code name for the field trials was "Kind 1534.") Let's call it Kodak Ektaline Paper. *It comes in the two usual speeds for oscillographs,* Kodak Ektaline 16 Paper *and* Kodak Ektaline 18 Paper. Kodak Ektaline Chemicals *come as liquids. The stabilization principle used in the automatic oscillogram processors came from Kodak, too. An inquiry to Eastman Kodak Company, Photorecording Methods Division, Rochester 4, N. Y., puts everything in place right up to the moment.*

A sharp eye for infrared

The decision to announce at this time the availability of *f/1 Irtran-2 Aspheric Lenses* has been reached in struggle against deeply rooted inhibitions. In the photographic film and paper trade we are habituated to a longer silence before the first blast of the trumpets.

These Irtran-2 lenses transmit usefully from 2μ to 14μ. Two focal lengths, 2-inch and 3-inch, are offered off the shelf. At *f*/1, we seem to have done well at providing high collecting-power for energy without undue sacrifice of sharpness. Sharpness was the goal. For both lenses, the minimum circle of confusion *computes* at less than .001″ for any wavelength from 4.25μ to 10μ. The italics mark where we hurt.

Much care and a valuable ingenuity have been exercised in impressing our tenth-degree equation upon the concave side of these meniscus lenses, in

The concave side is trickier.

grinding and polishing the spherical convex side, in placing the center of the spherical curvature on the axis of the asphere, in maintaining the center thicknesses at the 9.1 mm and 10.4 mm values respectively that the calculations assume, in the optical homogeneity of the Irtran-2 material. More than this we cannot claim. To the extent that the care and ingenuity have succeeded in making the calculations represent the actuality, the circle of confusion is less than .001″. The customer's willingness to take a chance that we have hit it will, in good sense, depend on how badly his project needs a 2μ-14μ infrared image of high definition and high aperture.

To demonstrate experimentally at those wavelengths that the circle of confusion is indeed that small is a task which we have simply been too busy to complete up to the time these words were written.

In the lead sulfide region, the sharpness does not compute to be as good as farther out in the infrared. Yet we have customers who use the lenses there and are happy with confusion-circle minima as large as .008″.

In comparison with reflective optics hitherto used, Irtran-2 aspheres offer compactness and a wider field that doesn't even show any appreciable deterioration as far as 2° off axis. You do give up the perfect achromatism of reflective optics. In the 2-inch lens the minimum circle of confusion for 10μ radiation is located 2 mm beyond the minimum circle of confusion for 4.25μ radiation; in the 3-inch lens the separation is 3 mm.

We have said enough to establish our frankness and to indicate whether there is any need for you to burden the long lines to Rochester, N. Y., LOcust 2-6000, Extension 5166, which is one way to reach Eastman Kodak Company, Special Products Division. Bear in mind that Irtran-2 material has a hardness of 354 Knoop, is not at all brittle, withstands thermal shock and the solvent action of water, and can get very hot without losing transparency or giving off toxic fumes.

Forced drafting

The truly creative mind tends to shy away from the petty problems of the drafting room. Then the creative mind gets angry and upset when damnable antiquated drafting procedures impede the swift and smooth transformation of its output into physical reality. Perhaps the petty problems are worth a few moments of the creative mind's time. They have solutions like

• speeding revision of drawings by picking up photographically everything from the existing drawing that is to appear in the revision

• converting drawings into rigid, dimensionally stable, non-staining, non-glaring, long-wearing overlays for contour projector screens

• making working drawings out of photographs of existing equipment instead of drawing everything

• photographic templates for standard or repeating elements in a drawing

• photographic intermediates for protecting original drawings, restoring old and worn ones, or avoiding waits for extra prints.

The Kodak Compass *is an irregular publication that will be sent free to whoever in your organization ought to be concerned with such matters. The first issue deals very plainly with pencils, inks, and eradication techniques for the new Estar Base drawing-reproduction films. Submit names to Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y. Same address for quick answers to questions stirred up by these remarks.*

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Kodak
TRADE MARK

Key number 24

they are the only really civilized people on this planet.

The possible advantages of space can be best appreciated if we turn our backs upon it and return, in imagination, to the sea. Here is the perfect environment for life—the place where it originally evolved. In the sea, an all-pervading fluid medium carries oxygen and food to every organism; it need never hunt for either. The same medium neutralizes gravity, insures against temperature extremes, and prevents damage by too-intense solar radiation—which must have been lethal at the earth's surface before the ozone layer was formed.

When we consider these facts, it seems incredible that life ever left the sea, for in some ways the dry land is almost as dangerous as space. Because we are accustomed to it, we forget the price we have had to pay in our daily battle against gravity. We seldom stop to think that we are still creatures of the sea, able to leave it only because, from birth to death, we wear the water-filled spacesuits of our skins.

Yet, until life had invaded and conquered the land, it was trapped in an evolutionary *cul-de-sac* — for intelligence cannot arise in the sea. The relative opacity of water, and its resistance to movement, were perhaps the chief factors limiting the mental progress of marine creatures. They had little incentive to develop keen vision (the most subtle of the senses, and the only long-range one) or manual dexterity. It will be most interesting to see if there are any exceptions to this, elsewhere in the universe.

Even if these obstacles do not prevent a low order of intelligence arising in the sea, the road to further development is blocked by an impassable barrier. The difference between man and animals lies not in the possession of tools, *but in the possession of fire.* A marine culture could never escape from the Stone Age and discover the use of metals; indeed, almost all branches of science and technology would be forever barred to it.

The Great Neutralizer

Perhaps we would have been happier had we remained in the sea (the porpoises seem glad enough to have returned, after sampling the delights of the dry land for a few million years) but I do not think that even the most cynical philosopher has ever suggested that we took the wrong road. The world beneath the waves is beautiful, but it is hopelessly limited, and the creatures who live there are crippled irremediably in mind and spirit. No fish can see the stars, but we will never be content until we have reached them.

There is one point, and a very important one, at which the evolutionary parallel breaks down. Life adapted itself to the land by unconscious, biological means, whereas the adaptation to space is conscious and deliberate, made not through biological but through engineering techniques of infinitely greater flexibility and power. At least we think it is conscious and deliberate, but it is often hard to avoid the feeling that we are in the grip of some mysterious force or *Zeitgeist* that is driving us out to the planets, whether we wish to go or not.

Though the analogy is obvious, it cannot be *proved,* at this moment of time, that expansion into space will produce a quantum jump in our development as great as that which took place when our ancestors left the sea. From the nature of things, we cannot predict the new forces, powers, and discoveries that will be disclosed to us when we reach the other planets or can set up laboratories in space. They are as much beyond our vision today as fire or electricity would be beyond the imagination of a fish.

Yet no one can doubt that the increasing flow of knowledge and sense impressions, and the wholly new types of experience and emotion, that will result from space travel will have a profoundly stimulating effect upon the human psyche. I have already referred to our age as a neurotic one. The "sick" jokes, the decadence of art forms, the flood of anxious self-improvement books, the etiolated cadavers posing in the fashion magazines—these are minor symptoms of a malaise that has gripped at least the western world, where it sometimes seems that we have reached *fin de siècle* 50 years ahead of the calendar.

The opening of the space frontier will change all that, as the opening of any new frontier must do. It has saved us, perhaps in the nick of time, by providing an outlet for dangerously stifled energies. In William James' famous phrase, it is the perfect moral equivalent of war.

From time to time, alarm has been expressed at the danger of "sensory deprivation" in space. Astronauts on long journeys, it has been suggested, will suffer the symptoms that afflict men who are cut off from their environment by being shut up in darkened, soundproofed rooms.

I would reverse this argument. Our entire culture will suffer from sensory deprivation if it does *not* go out into space. There is striking evidence for this in what has already happened to the astronomers and physicists. As soon as they were able to rise above

the atmosphere, a new and often surprising universe was opened up to them, far richer and more complex than had ever been suspected from ground observations. Even the most enthusiastic proponents of space research never imagined just how valuable satellites would actually turn out to be, and there is a profound symbolism in this.

But the facts and statistics of science, priceless though they are, tell only part of the story. Across the seas of space lie the new raw materials of the imagination, without which all forms of art must eventually sicken and die. Strangeness, wonder, mystery, adventure, magic—these things, which not long ago seemed lost forever, will soon return to the world. And with them, perhaps, will come again an age of sages and epics such as Homer never knew.

An Age of Transition

Though we may welcome this, we may not enjoy it, for it is never easy to live in an age of transition—indeed, of revolution. As the old Chinese proverb has it: "May you live in interesting times," and the Twentieth Century is probably the most "interesting" period that mankind has ever known. The psychological stresses and strains produced by astronautics—upon the travelers and those who stay at home—will often be unpleasant, even though the ultimate outcome will be beneficial to the race as a whole.

The American public has already experienced some emotional highs and lows that give a slight foretaste of what is to come. To date, the extremes are well represented by the explosion of the first Vanguard, and the success of the first manned suborbital shot, when the whole nation stopped its work and play to watch Cape Canaveral. But these are only pale shadows of such future triumphs and disasters as the landing on the moon—or the impact of a Nova-class vehicle on Miami Beach.

We must also prepare ourselves for the probability—in fact, the virtual certainty—that the most painful and uncomfortable shocks will involve our philosophical and religious beliefs. Many optimistic apologists have tried to deny this, but the clear verdict of history is against them.

We now take it for granted that our planet is a tiny world in a remote corner of an infinite universe, and have forgotten how this discovery shattered the calm certainties of medieval faith. Even the echoes of the second great scientific revolution are now swiftly fading. Today, except in a few backward regions, the theory of evolution arouses as little controversy as the statement that the earth moves round the sun. Yet it is only a hundred years since the best minds of the Victorian Age tore themselves asunder because they could not face the facts of biology.

Space will, sooner or later, present us with facts that are much more stubborn, and even more disconcerting. There can be little reasonable doubt that, *ultimately*, we will come into contact with races more intelligent than our own. That contact may be one way, through the discovery of ruins or artifacts; it may be two-way, over radio or laser circuits; it may even be face to face. But it will occur, and it may be the most devastating event in the history of mankind. The rash assertion that "God made Man in His own image" is ticking like a time bomb at the foundations of many faiths, and, as the hierarchy of the Universe is disclosed to us, we may have to recognize this chilling truth: If there are any gods whose chief concern is man, they cannot be very important gods.

The best examination I have seen of the probable effects of space travel upon our philosophical-religious beliefs was made in a broadcast by Derek Lawden, well-known for his work on interplanetary orbits. Because few people outside New Zealand will have heard his stimulating talk, it is worth giving Prof. Lawden's conclusions at some length:

> "I think man will see himself as one agent by which the whole universe of matter is slowly becoming conscious of itself. He will cease to feel an alien creature in an indifferent world, but will sense within himself the pulse of the cosmos. He'll become familiar with the marvelous and varied forms which can be assumed by matter . . . and he's certain to develop a feeling of reverence for the awe-inspiring whole of which he's a very small part. I suggest to you that his reaction to these impressive experiences will find its expression in a pantheism which will at last provide a philosophy of life and an attitude to existence which is in harmony with science . . . It may be objected that the physical universe could never become the object of worship. I ask anyone who denies this possibility to turn his eyes skyward on a clear night . . . Others may object that such a religion would possess little moral content. I would reply that this is by no means self-evident, but that, in any case, the conjunction of religion and ethics . . . is certainly not invariable; in fact, there's an excellent case for keeping the two separate . . . Morality in the modern Western world has been greatly weakened because of its strong ties with Christianity, for as one decays, so does the other."

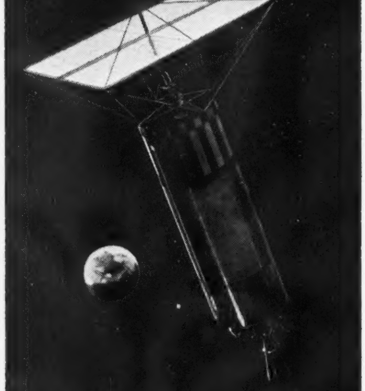
These are hard sayings, which many will find unpalatable. The truth may be yet harder. Perhaps if we knew all that lay ahead of us on the road to space—a hundred or a thousand or a million years in the future—no man alive would have the courage to take the first step. But that first step—and the second—has already been taken. To turn back now would be treason to the human spirit, even though our feet must some day carry us into realms no longer human.

Responsibilities Are Great

The eyes of all the ages are upon us now, as we create the myths of the future at Cape Canaveral and Kapustin Yar. No other generation has been given such powers, and such responsibilities. The impartial agents of our destiny stand on their launching pads, awaiting our commands. They can take us to that greater Renaissance whose signs and portents we can already see, or they can make us one with the dinosaurs.

The choice is ours, it must be made soon, and it is irrevocable. If our wisdom fails to match our science, we will have no second chance. For there will be none to carry our dreams across another Dark Age, when the dust of all our cities incarnadines the sunsets of the world. ♦♦

For Power in Space



Artist's rendering of General Atomic's thermoelectric power generator as it might appear when extended from a space vehicle operating near Mars. The lightweight solar panel powerplant would use an array of 0.1-in.-thick thermoelectric panels joined together to collect solar energy. The 1-kw generator shown here, under development for the AF, might weigh as little as 80 lb.

SFRN and the Nation

(CONTINUED FROM PAGE 67)

space flight. This alone would be worth many times the cost of our astronautical adventures. And we must not forget the effect an inspirational challenge can have on education. With an entire solar system to seek out and explore, our citizenry will want to sharpen its intellectual tools. This means a more informed populace, a great asset in any age.

We are all aware that the nation controlling space may control the earth. It is almost impossible to see how an astronautically second-rate nation can defend its interests and maintain a leading position in the world. Thus, in carrying out our ambitious space programs we find ourselves buying something else: Security. Like many intangibles, it has great value, and cannot be purchased at bargain rates.

There are countless examples of products and techniques originally developed for space applications that have already found their way into the civilian economy. Some have potential applications that can be visualized in broad outline today, while others may only become commercially profitable after additional years of research and development. It is often impossible to know when and how scientific research and exploration will pay off; we have been repeatedly surprised in the past and will continue to be surprised in the future.

Even today, there are multimillion-dollar companies that derive the majority of their income from products and services that were either unknown or undeveloped a decade ago. As one company executive was heard to say: "We are as interested in the useful pieces of outer space as the peaceful uses of outer space." Just as atomic energy found its way into such widely diversified fields as industrial and medical isotopes, food irradiation, nuclear submarines, and miniature power packages, so the products and techniques of space research are rapidly moving into our everyday life.

Space medicine and bioastronautics, for example, have given us greater insights into the workings of the human body and mind and the interrelationships between man and his environment. Anti-radiation drugs developed for astronauts traveling through the Van Allen Radiation Belts may well be critical for civilian protection in the event of atomic attack. Miniaturized medical instruments can be placed in important locations on the human body, thus permitting long-period measurements to be made; and special electronic devices have been created

by space medical researchers that can more accurately than ever before measure body temperatures and blood flow rates. Techniques developed to monitor the physical fitness of space pilots may have important applications elsewhere. The Mercury astronauts wore tiny electrodes 1.5 in. in diam taped to their bodies for the measurement of cardiac activity while they rocketed through space in their capsules. These electrodes picked up signals, generated by the heart's activity, which were amplified for transmission with other Mercury telemetry.

Because of the demands of space medicine, the state of the art of bioinstrumentation has advanced rapidly. Already this instrumentation has been superseded by even smaller components, consisting of complete FM transmitters smaller than a nickel to broadcast heart signals up to distances of 150 ft. These little components were made possible because of recent technological advances in microcircuitry and solid-state physics. Already an all-electronic hospital built around these and other bioastronautical instruments is being planned.

Our diet has been influenced to an extent by nutritional experiments: Concentrated lightweight food products developed for spacecrews have found their way into our drug stores and supermarkets as diet reducing bars. Such products are also important for civilian defense and emergency Red Cross food stockpiles. Even a rocket propellant has been found to have medical value. A derivative of hydrazine is used to treat a number of mental disorders, as well as tuberculosis.

The best known of all commercial applications of space technology is the communication satellite, several of which will soon provide relatively low-cost telecommunication relays connecting many points of the earth. Later will come worldwide television and radio broadcasting, certain to have an important effect in bringing the people of the earth closer together than ever before. It has been estimated that the tax revenues alone from communication satellite operations will, in the not too distant future, exceed the entire annual NASA budget.

Satellite weather forecasting offers a tremendous benefit for all mankind. Think of the human lives and misery that will be spared by being able to predict hurricanes and typhoons accurately. Literally billions of dollars may eventually be saved by farmers, businessmen, builders, shipping companies, airlines, tourist resorts, and tourists themselves, since so many of their activities are influenced by the weather and the lack of precise forecasting.

It is still too early to assess the full benefits that may accrue from devices being developed to analyze remotely other worlds, but, while on the subject of weather, it is definitely practicable to establish remote weather stations to broadcast periodic reports of local conditions. Such stations would incorporate power supplies and telemetry gear typical of those used in spacecraft.

Rockets themselves have begun to prove profitable from a non-military point of view. American manufacturers are selling a variety of atmospheric sounding vehicles to domestic and foreign markets. Soon, perhaps, long-range missile mail delivery will prove feasible, giving us the ability to transport letters and packages within hours to many parts of the world. Intercity mail would only take minutes.

It is hard to find a single aspect of missile and space technology for which a commercial application has not been found. The genius of American industry and the aggressiveness of its sales force see that no idea is overlooked. We find thermoelectric devices originally developed to provide spacecraft power now being used for industrial heating and cooling. The widespread use of computers in American industry today is largely attributable to their development and refinement for use in and with spacecraft and aircraft. With the employment of such recently developed techniques as microminiaturization of components and the use of magnetic logic elements, we now have rugged, accurate, but small computers. These manufacturing methods came about through the need to make smaller and lighter devices for space work.

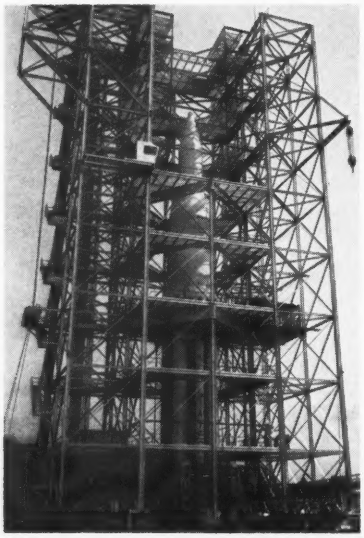
By 1964, it is estimated that $187.5 million will be spent on airborne and spaceborne digital computers. Soon computers will be as common in brokerage houses and merchandise inventory control centers as in space vehicles and launching bases. Already, many thousands of badly needed scientists have been relieved of tedious desk computing tasks so that they can do more creative thinking.

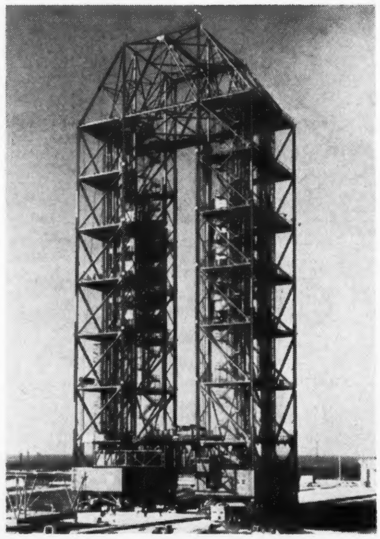
The mining industry has found jet drilling profitable in certain types of very hard rock areas. The making and handling of cryogenic fluids is an entirely new technology, and one that will have important civilian potential in the years to come. Solar cells and nuclear power supplies, developed for satellites and space probes, are gradually finding their way into our everyday living. Plasma research for propulsion systems has yielded a by-product method of producing electricity for our homes and factories. And plasma arc torches are now employed to work certain ultrahard materials. Speaking of materials, pyroceram, once almost exclusively used in missile radomes, is now found in cooking utensils, and epoxy missile resin is good for plastic tooling, metal bonding, and laminating applications. Infrared techniques, developed primarily for air-to-air missile guidance, have applications in the analysis of certain petroleum refining processes. And surface-to-air missile target location measuring devices have been adapted to surface surveying techniques with very important consequences.

Many of the products and byproducts of the space age are on view this month at the New York Coliseum as the feature attraction of the ARS SPACE FLIGHT REPORT TO THE NATION. The purpose of this meeting is not only to provide an authoritative review of the many technical fields on which the advancement of the national space program depends, but to present a comprehensive display of the products, materials, equipment, and services created during the last few years, and to review for the public the true meaning of our efforts to move even more deeply into space. ♦♦


ACTION!
Major advances, coming in increasingly rapid succession from the leaders of the solid rocket propulsion industry, give dramatic evidence of the quickening pace of this nation's big booster effort.
The next major achievement will be the firing soon of a giant operational prototype solid rocket of approximately one-half-million-pounds thrust at UTC's Development Center.
U T C
UNITED TECHNOLOGY CORPORATION
A subsidiary of United Aircraft Corporation
P. O. Box 358 • Sunnyvale, California
Capability backed by four decades of propulsion experience

Saturn Moves Toward Flight-Test Stage





Left, first flight configuration of Saturn C-1, assembled in dynamic test stand at NASA Marshall Space Flight Center. Right, 310-ft Saturn service tower, part of Launch Complex 34 at Cape Canaveral.

Saturn moved toward the flight-testing stage in recent months with assembly of the first flight configuration, complete with fins for added stability, in the new dynamic test stand at the NASA George C. Marshall Space Flight Center, and completion of the Saturn launch complex, known as Launch Complex 34, at Cape Canaveral.

The 204-ft dynamic test stand at Huntsville permits checkout of the mechanical mating features of the vehicle, determination of the natural bending characteristics, and the effect of simulated flight vibrations on different stages. Fueling procedures will also be practiced while the vehicle is in the tower.

Eye-catcher in the Saturn launch complex at the Cape, built at a cost of $14 million for NASA by the Army Corps of Engineers, is a 310-ft service tower said to be the highest mobile self-propelled vehicle on earth. The huge 2800-ton tower was built by the fabricating division of Kaiser Steel under a $4 million Corps of Engineers contract.

Space Medicine

(CONTINUED FROM PAGE 59)

underwater nuclear-submarine cruise, in which the crew lived and worked in very close quarters harmoniously and with a minimum of behavioral difficulty or emotional instability. Further research will be required to select crews of three and more to participate in space flights lasting from a few hours to much longer periods of time. There will be need for manning permanent space stations and lunar bases with congenial and efficient crews.

Other research underway covers perception, performance in guidance, control, and navigation of spacecraft while under stress, and social and sensory isolation. An example of a difficult task is manned control of the reentry path of a spacecraft with aerodynamic lift, such as an advanced Dynasoar, so that its tremendous energy may be dissipated correctly. Experience with the X-15 will be most helpful here.

Biomedical Data Collection, Processing, and Utilization. The use of electronic devices in life-science research is rapidly extending man's intellect by providing him more time for basic creative thought. Simon Ramo has recommended reducing the intellectual activity to stored and incoming information, to logical processes, to sorting, and to deciding, and assigning to electronic units that part that is well understood and that involves rates and quantities too large for the human mind. This frees the intellect for complex parts of a task, above the routine work of the electronic computer.

Woodbury has emphasized that all of the life sciences have the following in common: That something is observed, selected for recording (sampled), collected and recorded in one form or other (coded), operated on, (analyzed), presented to the observer (displayed) or put away for further use (stored), and in most cases used later (retrieved). On-board data compression is an objective in spacecraft. A major reason for slow utilization of the revolutionary improvements in data handling in the life sciences has been lack of personnel familiar with the use of such equipment and with what type of processing is appropriate once the computer state is reached.

Processing Medical Data

But some progress has been made in this direction. All the information concerning each one of the astronauts was placed on color-coded IBM cards designed by one of the authors (A.H.S.). The use of these cards frees more of the physician's time and talents for diagnosis and study and insures accuracy and comparability of records, as well as ready accessibility to data. Marks are made on the cards with a special electrographic pencil. New information can be easily programmed.

Any system adopted for machine processing of medical data should be of great utility because of the capability to recall or retrieve information promptly and completely any place in the world where there is a communication network. Among the possible uses are the following:

1. Complete review of all pertinent medical, physiological, and psychological characteristics.
2. Comparison of present and past status in regard to any chosen characteristic.
3. Assessment of current status of qualification for a given mission task.
4. Rate of progress compared to norms and averages.
5. Study of individual alterations which might result from repeated space flights, aging deterioration, pathological processes, and the like.
6. Prediction of future career limitations from evidence indicating a deterioration pattern in some significant characteristic.
7. Estimation of the rate of physiological aging rate (PAR) as compared to chronological age.

During all phases of space missions there is a requirement for continuous, real-time, precise, integrated, and valid indications of the physiologic condition of the crews and any departure from their normal range during experi-

ments, activity, rest, inattentiveness, sleep, or an emergency. Early warning of impending disaster can save lives. Changes in environmental support system or in-flight plans can be accomplished rapidly by a competent ground-based biomedical observer. On-board changes can eventually be accomplished by on-board computers. Such information was obtained in excellent form from astronauts Shepard and Grissom during their flights. Research is continuing on the parameters to be measured, biomedical transducers (including one that has a digital output), methods of data acquisition and transmission, the elimination of non-pertinent data, analog and digital displays, and editing and diagnostic programming. At the moment a blood-pressure device is being evaluated.

Eventually, Riley and his associates at Lockheed predict, there will be medical instrumentation to retrieve, store, and analyze the relationships of body functions, such as pressure, flow rate and volume, electrical potential and movement. This will require very flexible and compact instrumentation that will not affect the reactions of the subject. There is an urgent requirement for units with subminiature transistorized differential amplifiers and FM transmitters for use in any dynamic situation in which a radio transmission link is more desirable than a direct connection to the physiological monitoring equipment.

Automatic Monitoring

Automatic electronic monitoring of pulse, temperature, respiration, blood pressure, and other pertinent information for post-operative patients or those critically ill will in large part continue to be a direct outgrowth of research in aerospace medicine. These sensor units can be connected up with signaling panels at a nurse's station or other place of observation. The units and displays can be preset for an analog or digital presentation when any of the body functions being measured begin a trend or make a change that is significant or dangerous. A visual or auditory warning device can also be used. For example, a continuous recording of blood pressure can be made by means of an automatic-cycling blood-pressure unit and a warning flashed if it starts to drop below normal levels.

Further research is continuing on simulators to check diagnostic programming, to check out the worldwide systems communication networks, including tracking procedures, and to train the spacecraft and ground-based monitoring crews. The simulator used for training spacecrews should have six degree of freedom, real-time cockpit simulation and, whenever possible, simulation of single and multiple stresses. Among the advantages of such simulators are the low cost per flight, insurance of optimum crew performance during the first flight, and safety.

Environmental Stress. An accelerated research program on an international basis is essential to establish—in realistic environmental simulators on the ground and in larger and larger spacecraft—the effect of single as well as combined stresses that occur in space with respect to the following thresholds of performance degradation in man:

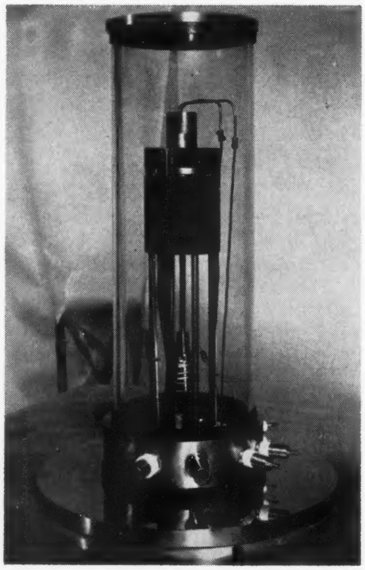
1. Degradation from fine performance.
2. Gross degradation.
3. Gross degradation with reversible tissue damage.
4. Short and long time degradation with irreversible tissue damage.

Acquisition of as much scientific information as possible under controlled conditions should be accomplished in earth-based laboratories and by the use of balloons and rockets prior to spacecraft missions. This is the most economical and satisfactory method. Information from such programs generally helps in developing or improving and calibrating scientific equipment to be carried aboard spacecraft and in interpreting the data derived from space experiments. For example, radiation cannot be seen, felt, or heard; but there are excellent detection devices and early-warning schemes, and adequate shielding can give protection. Eventually, of course, there will be orbiting space stations for the exposure of spacecrews under carefully controlled conditions to the environment of space and for experiments and training programs, including rendezvous. Establishment of permanent lunar bases will provide an extensive training and research program.

The effect of combined stresses such as heat, exposure to high percentages of oxygen, rotation, oscillation, vibration, and acceleration—including changing from weightlessness to positive-g—requires research to determine whether the degradation is additive, what the cumulative affect is, and what the effect is on the various systems of the body, particularly those that have to do with the interpretation of displays and the use of controls. Eventually, when vehicles such as the Dynasoar are capable of aerodynamically efficient flight, the pilot, within certain limits, can vary the physiological stresses he and his crew are undergoing, and will have very good control of his landing site.

Utilization of modified Mercury capsules, the global-tracking network, and operational experience for a program of in-flight experiments of 2, 6, 10 and 14 days have been proposed to provide continuity of research effort consonant with technological advances. Accomplishment of these goals necessitates a long-range effort, so that the shorter-term objectives will be attained as well as a broad base for future research and development programs in this field. At the completion of this program, knowledge of the effects of the environment of space on man will have been substantially increased, and

New Thermionic Converter



Close-up of thermionic diode in its bell-jar vacuum chamber.

The Thompson Ramo Wooldridge Tapco New Devices Laboratories has announced two significant advances in thermionic power systems. Recent performance tests carried out by Tapco under an AF Systems Div. contract indicate that a new thermionic converter design delivered an actual efficiency of 13% at the 200-w power level, the company reports, while, in other tests under the same contract, a new approach to solar concentrator fabrication is said to have produced unmatched solar concentration efficiencies.

The thermionic converter is electron bombardment heated, while the solar concentrator is fabricated by an electroforming process which allows accurate reproduction of a high-precision matrix die. Surface reflectivities up to 92% are claimed.

there will be a broad base to proceed on.

Acceleration. In space flight many mechanical factors and forces occur that are encountered only in small measure at ground level. Large forces pin down the astronaut during initial acceleration and re-entry, as well as during emergency escape. Spinning, tumbling, buffeting, vibration, and noise present environmental stresses which require further study.

Successful future space flights by man require that detailed information be obtained on the human tolerance limits to the rapidly changing accelerations which occur in different missions. From a protective standpoint, data from the Naval Aviation Medical Acceleration Laboratory has demonstrated that submersion of the pilot in water appreciably increases his tolerance to acceleration. Dynamic space-flight simulation has been studied on the centrifuge at the same laboratory. Included in the simulations are the use of displays, controls, noise, and vibration. The effects of transverse acceleration are being studied by Wood at the Mayo Clinic centrifuge. The advantages of a contour couch with the necessary restraints have been demonstrated successfully by the astronauts.

In order to study whole body vibrations, including effects on vision, speech, and heavy organs, a large vertical accelerator is in use at the Aero Medical Laboratory at Wright Field that can be programmed to provide any desired vertical acceleration pattern in the frequency range of 0–10 cps, with control of amplitude and duration.

At the Naval School of Aviation Medicine in Pensacola, Fla., a slow-rotation room is being used to do research on measuring positive functioning of the non-acoustic labyrinth. Normal functioning of the semi-circular canals can be determined.

Existing acceleration devices in England, Sweden, Italy, France, and other countries run programs that contribute materially each year to solving the problems of acceleration that occur in space flight.

Weightlessness. This state presents unusual problems because its simulation for prolonged periods can only be achieved in satellites or spaceships. A number of consequences are possible according to NASA. Certain physical properties of matter in the solid, liquid, and vapor states may be significantly affected. The method of heat convection and diffusion may be radically altered. It is possible that intracellular events could occur in different time sequences. Many physiological variables may undergo change —for example, neuromuscular and cardiac function, circulation, vestibular function, and metabolism. The sensory basis for normal body orientation will be altered. The effects of gravity-free states and various low-gravity conditions require investigation. Only space programs of longer and longer duration will reveal the time it takes to adapt to weightlessness, to adapt to one-sixth gravity on the moon, and to re-adapt to the earth's gravity on return.

Radiation. NASA recognizes that radiation in space presents a great challenge to physical as well as biological scientists. There are intense and not fully explored radiation belts in the magnetic field surrounding the earth. In addition, many particles arrive on the surface of the earth from space and from the sun. Some of these have not as yet been fully explored, and only part of the radiation spectrum has been reproduced at ground level in accelerators to date. Research will include additional physical measurements and biological assay of all the radiations in space, their simulation at ground level, and finally direct experiments on living material of all types in satellites to provide quantitative empirical information on various biological effects, not only on immediate metabolism and function but also on survival, longevity, carcinogenesis, and mutations.

The astronauts, depending on the mission, can be exposed to radiation from numerous sources, including the earth's Van Allen Belts, cosmic radiation, solar flares, and nuclear reactors or powerplants. Prediction of solar flares would prove most helpful.

Shielding in flight and in lunar bases should be against all the different types of radiation hazards. Consideration has been made for partial body shields that will afford adequate protection for short exposure times, as during a solar flare. The bone marrow in the extremities would be damaged. The advantages of rapid transit through radiation belts, special orbits, and the use of drugs are under consideration.

What Radiation Dosage?

Adequate biological shielding could require a major fraction of the available payload on a lunar or Mars mission. This brings up the question of increasing the present acceptable acute radiation dosage from 25 to 75 rem, with a resultant appreciable decrease in shielding requirements. Equipment also must be developed to monitor continuously the total integrated radiation exposure any member of a crew receives during a space mission.

Radiation measurements for correlation with biological studies are planned by NASA's Goddard Space Flight Center. Nuclear emulsions and tissue-equivalent ionization chambers will monitor the energy spectrum and variation of primary cosmic radiation above the earth's atmosphere and below the Van Allen zones. These combined studies will make a basic scientific contribution as well as further determine the acceptability of longer term manned space flight.

Nuclear Propulsion. From a medical viewpoint, the promising future of nuclear propulsion has the following advantages for lunar missions:

1. Chemical rockets weigh more than double the weight of boosters that use a nuclear second stage. The payload is appreciably increased.

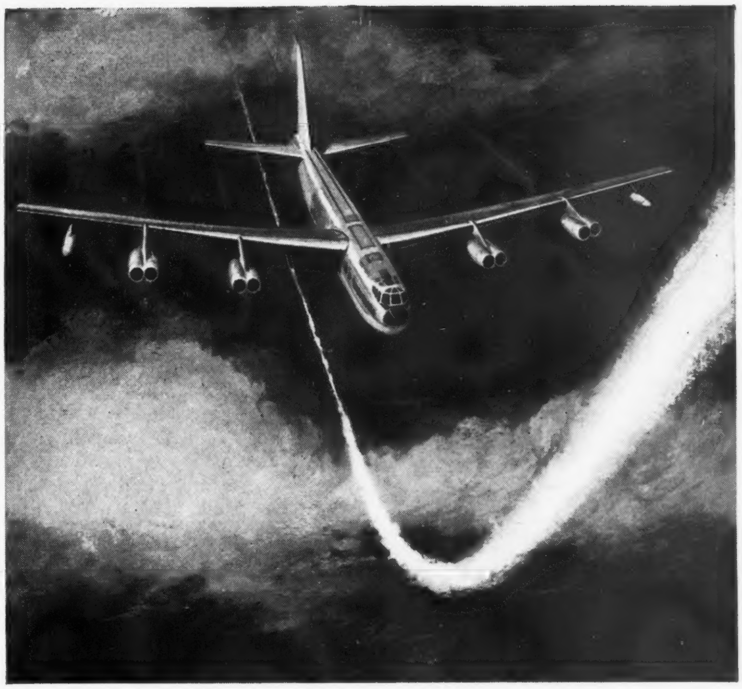
2. Reductions in the weight and size of the vehicle make it easier to develop the launch site and ancillary services.

3. The total integrated fission yield of such a vehicle is very, very small.

4. Only shadow shielding is needed in space. If additional amounts of shielding are required to protect the

1961–62 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
1961			
Oct. 2–7	XIIth International Astronautical Congress	Washington, D.C.	Past
Oct 9–15	ARS SPACE FLIGHT REPORT TO THE NATION	New York, N.Y.	Past
1962			
Jan. 24–26	Solid Propellant Rocket Conference	Waco, Tex.	Oct. 20
March 14–16	Electric Propulsion Conference	Monterey, Calif.	Nov. 20
April 3–5	Launch Vehicles Structures and Materials Conference	Phoenix, Ariz.	Sept. 15



KEARFOTT is producing

precision floated gyros for the

Skybolt missile

***Engineers:** Kearfott offers challenging opportunities in advanced component and system development.*

KEARFOTT DIVISION
Little Falls, New Jersey

GENERAL PRECISION, INC.
Other Divisions: GPL, Librascope, Link

Key number 87

crew from natural radiation in space, then the all-nuclear vehicle again becomes more attractive relative to chemical propulsion.

Research is underway on the neutron and gamma-ray leakage fluxes during the testing of prototype nuclear-propulsion reactors at the Nevada test site. During ground testing of fission reactors, continuous studies should be made on fall-out particle size and distribution.

In order to determine the biologic effects of nuclear rockets in space, it is essential to have information on the fission products formed and their distribution, and the biologic effect of their inhalation. Such a program has been started by the Atomic Energy Commission's Division of Biology and Medicine as a part of the Lovelace Foundation's program.

Changes in Ambient Time Cycles. On earth, living organisms are geared to a 24-hr cycle and diurnal periodicity occurs in most biological variables. Crews on spaceships or planetary stations will adjust with varying degrees of success to other cycles. The problems of physiological and psychological adaptation are broad ones which can be studied in terrestrial as well as extraterrestrial laboratories.

Safety and Reliability. Man's versatility, selectivity, and background of knowledge and experience enable him to react intelligently to unanticipated situations and to inspect objects to a degree not simulated by any combination of physical devices, however complex, which have been developed or are even contemplated. Human intelligence and manual skill in servicing, repairing, and maintaining the complicated mechanisms of space vehicles or repairing breakdowns in flight are not readily dispensed with. Man's capability for voice communication permits him to send detailed descriptions and to receive information whereby the concerted judgment of others may be brought to bear on unforeseen problems that arise in flight. This in turn increases his reliability.

The farther man goes away from earth, the more difficult it is to insure his safe existence and return. He must live and work in a pressurized space vehicle in which oxygen, food, and other requirements are provided, as well as means for the absorption of carbon dioxide and contaminants, disposal of wastes, and protection against radiations. Hazard analyses are made of each component of the life-support environmental system and other systems in the spacecraft. Safety is considered on a total system basis; causes and trends of accidents or malfunctions are identified, isolated, and studied.

SOP's for Emergencies

The Mercury-Redstone Emergency-Egress Committee—representing the combined effort of capsule, booster, and Atlantic Missile Range personnel—have prepared a classic-procedure handbook to cover the general types of major failures that could exist for eight combined vehicle-complex conditions during countdown and launch operations. They developed procedures designed to provide maximum safety for the astronaut with minimum hazards for the rescue personnel.

Research is underway on the basic causes of human error with or without stress, the development of hazard and reliability criteria for the space vehicle and its components on a total system basis, and the development of protective and emergency equipment. Spacecraft with lift will have a wider re-entry corridor, thereby decreasing the probability of a high deceleration load on re-entry. Unmanned satellite programs are underway by NASA to determine the parameters of micrometeoroid penetration.

Standby crews and vehicles will be available in the future to go to the rescue of crews in space or on other planets in an emergency.

Andrew Haley has pointed out the need of an international code of space medicine, covering the sterilization of interplanetary vehicles. In formulating such a code, one must strongly emphasize the necessity of thorough coordination with the technicians and scientists who must eventually comply with the code provisions.

Extraterrestrial Life. The major objectives of space research in the NASA life-sciences program are twofold, according to Roadman and his staff: (1) Investigation of the effects of extraterrestrial life, and (2) scientific and technologic advances related to manned space exploration.

In connection with the first objective, among the most perplexing questions which have challenged men's minds are the nature and origin of life and the possibility of its presence elsewhere in the universe than on the earth.

Research will include the further development of hypotheses relating to the origin of complex organic molecules and of living matter, further observation, both from the earth and from artificial satellites, of the surface environments of neighboring celestial bodies, studies on the adaptive effects of simulated extraterrestrial environments on various forms of life in successive generations, the study of meteorites and "cosmic dust," and, eventually, the exploration by man of lunar and planetary surfaces for complex molecules, organic substances, or evidence of life forms.

Thus space medicine can be viewed as one of the more important direct links between this program of space research and exploration and man's community of everyday affairs on his home planet. ♦♦

Outer Space and the Law

(CONTINUED FROM PAGE 65)

that it should have the status of the high seas as accurately stated in 1826 by a great American jurist, Mr. Justice Storey of the Supreme Court, in the case of "The Marianna Flora."

"Upon the ocean, then, in time of peace, all possess an entire equality. It is the common highway of all, appropriated to the use of all; and no one can vindicate to himself a superior prerogative there. Every ship sails there with the unquestionable right of pursuing her own lawful business without interruption; but whatever may be that business, she is bound to pursue it in such a manner as not to violate the rights of others."

The world has used the high seas as a transport medium since prehistoric times. For at least two centuries, States have accepted the fact that its use is free to all. Likewise, we have accepted the legal doctrine that every ship has nationality and that the State of the flag is thereby responsible for its international good conduct when away from home. With this background, international law has built up the rights and responsibilities between States as to the use of the high seas and the rights and responsibilities between citizens of the same State, or between citizens of different States, when traveling on the high seas.

If outer space has the same status as the high seas, the remainder of the structure to be provided by the law must be determined by international agreement, a reasonably practical task if the world desires to live in peace. Necessary rules and regulations could be provided by an international convention or the nations of the world could by agreement delegate to an international organization the power to adopt rules thereafter to be enforced as law. But first the foundation must be established.

Many groups, especially since Sputnik I was launched, have studied these

"Surveyor Lunar Spacecraft"

WE PROMISE YOU A REPLY WITHIN ONE WEEK

FIRST CLASS
PERMIT NO. 91
CULVER CITY,
CALIFORNIA

BUSINESS REPLY CARD

No Postage Stamp Necessary if Mailed in the United States

Dr. F. P. Adler, Manager
Space Systems Division
Hughes Aircraft Company
11940 W. Jefferson Blvd.
Culver City 1, California

Personal and Confidential

AEROSPACE & WEAPONS SYSTEMS ENGINEERS

Consider these representative openings:

These are only a few of the hundreds of openings for both junior and senior graduate Physicists, Electronic Engineers, Thermodynamicists, Mathematicians, Mechanical Engineers and Aeronautical Engineers. To qualify, you should have training or experience which can be applied to space systems analysis, vehicle design, controls, propulsion, missile defense or related areas. We invite your inquiry.

Control System Analysts

Requires engineers at various levels of experience including senior men capable of taking over-all project responsibility in the synthesis and analysis of control systems.

Senior Dynamicists

Must be capable of performing advanced analysis in structural mechanics. Will be required to calculate response of complex elastic systems to various dynamic inputs including random excitation. Must be capable of original work in developing advanced analytical techniques.

Aerothermodynamicists

Experience in hypersonic gas dynamics, heat transfer, ablation, re-entry vehicle design and shock layer ionization will be most useful.

Systems Analysts

Senior engineers and physicists to investigate such questions as: What are the optimum guidance systems for lunar and interplanetary space flight; how are the system choices justified considering trade-off of choice in terms of cost effectiveness; what are the IR systems requirements for ballistic missile defense; what are the optimum signal processing techniques for inter-planetary telecommunications; what are the maintenance and logistic requirements for weapon systems; what are the requirements of manned space flight?

Orbital Mechanics Analysts

Trajectory analysis and solution of problems involving conic and perturbation techniques.

Space Power Engineers

Openings include development of electronic propulsion systems for space probes. Positions call for capability of working in either a project or research capacity on direct energy conversion and storage systems. Openings exist for both junior and senior engineers. An advanced degree in Electronics or Physics is preferred.

Armament Control Analysts

Experience in the synthesis of integrated fire control loops including the tie-in of sensing and guidance equipment is desirable. A strong background in target data sensing devices, particularly at optical wavelengths, is very helpful, as is experience with computers.

Instrumentation Engineers

Involves the integration of advanced instruments into spacecraft such as Surveyor. Includes design for in-flight reliability; technical direction of instrument subcontractors; development of test programs and test equipment; and determining instrument interactions. Experience with subcontract procedures is also helpful.

PLEASE COMPLETE THE ATTACHED CARD so that we may become acquainted with your interests and qualifications. Or write: Dr. F. P. Adler, Manager, Space Systems Division, Hughes Aircraft Company, 11940 West Jefferson Boulevard, Culver City 4, California. We invite your inquiry and...

We promise you a reply within one week

creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY

SPACE SYSTEMS DIVISION

An equal opportunity employer.

and other problems involved in the construction of a legal framework for the extension of human society into outer space. Such purely legal groups as the International Law Assn., the American Bar Assn., and the American Society of International Law are making most valuable contributions. Of equal importance is the fact that engineering groups have now realized that the law as a social engineering science must take its part in the future development and use of outer space. The American Rocket Society, for example, several years ago established a Technical Committee on Space Law and Sociology. More recently, the International Astronautical Federation, of which ARS is a member, took somewhat similar action. At its 1960 conference in Stockholm, it approved the statutes of two affiliates, the International Academy of Astronautics and the International Institute of Space Law. Membership in the Academy is divided into three sections—basic sciences, engineering sciences, and life sciences. The latter includes "medical and other sciences dealing with life and survival in space," and jurists were included in the original founding membership of this section.

Institute Tasks

The purposes of the International Institute of Space Law include "carrying out tasks which may be considered desirable for fostering the social science aspects of astronautics, space travel, and exploration." In 1959, while the institute was in process of organization, the IAF at its London conference authorized Andrew G. Haley, its General Counsel, to name Working Groups to consider and report on questions of space law. These Groups are now part of the Institute. They are dealing with such questions as the legal status and boundaries of airspace and outer space, the legal status of rocket and space vehicles and of celestial bodies, radio regulation for space-flight activities, damage caused by space vehicles, and other cognate subjects. The conclusions will be made available to such international governmental organizations as may hereafter be charged with drafting an agreement to build a legal framework for outer space.

Theodore von Kármán, as director of the Academy, desiring to assure cooperation between the work of the Academy and of the Institute, appointed in 1960 a joint commission on "Technical Aspects of Space Law." L. R. Shepherd, past president of the British Interplanetary Society and a former president of the IAF, was named vice-chairman, with this writer as chairman. This commission will seek first to analyze questions of sovereignty in space. As Dr. Shepherd has stated: "The scientific problem is that of defining meaningful physical criteria upon which legal rulings might be based. Obviously there can be no single phenomenon which gives a clean cut answer to this problem and final resolution of the matter could only come from a careful consideration of a number of relevant physical phenomena."

But the work of any nongovernmental group must in the last analysis be purely advisory. Certainly it must be the task of the United Nations to build the actual framework to support any future human society in outer space. The UN has in fact tacitly acknowledged the need for action. On Dec. 12, 1958, the General Assembly adopted a resolution which recognized "the common interest of mankind in outer space, and that it is the common aim that it should be used for peaceful purposes only." The same resolution created an Ad Hoc Committee of certain member States and directed it to report on various questions including "the nature of legal problems which may arise in the carrying out of programs to explore outer space." Unfortunately, certain of the States appointed to membership on the Committee refused to participate in its deliberations. However, the majority went forward and on July 14, 1959, filed a report concurred in by representatives of Argentina, Australia, Belgium, Brazil, Canada, France, Iran, Italy, Japan, Mexico, Sweden, United Kingdom, and the United States.

This report is a historic document. Perhaps its most important contribution is the finding that the principles of the United Nations Charter and of the Statute of the International Court of Justice are not limited in their operation to the confines of the earth. If this recommendation is finally accepted, it means that the rule of law in outer space or on any celestial body hereafter occupied by any member of the UN will be governed by the broad terms of the Charter.

On the basic question of whether outer space shall be free for the use of all nations, the report indicated that launchings during the IGY 1957–1958 and subsequently were "on the premise of the permissibility of the launching and the flight of the space vehicles which were launched regardless of what territory they passed 'over' during the course of their flight through outer space." The Committee then indicated that with this practice "there may have been initiated the recognition or establishment of a generally accepted rule to the effect that, in principle, outer space is, on condition of equality, freely available for exploration and use by all in accordance with existing or future international law or agreements." While this statement is somewhat cryptic in its terms, it may properly be taken as a clear indication that the national sovereignty of States carrying with it unilateral flight control should not be extended into outer space.

However, the Committee decided that the determination of "precise limits for airspace and outer space did not present a legal problem calling for priority consideration at this moment." With this latter conclusion I must disagree. The dividing line must be established, for certainly the entire report is an acknowledgment that flight in the airspace and flight in outer space are not subject to the same regulations.

The Ad Hoc Committee report was not formally considered by the UN General Assembly, presumably because of non-participation in its preparation by certain important States. Instead, in December 1959, a new "Committee on the Peaceful Uses of Outer Space" was established consisting of Albania, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Czechoslovakia, France, Hungary, India, Iran, Italy, Japan, Lebanon, Mexico, Poland, Roumania, Sweden, USSR, United Arab Republic, United Kingdom, and the United States.

Directives Are Similar

The directives to the new Committee are quite similar to those given to the Ad Hoc Committee. Among other things, the new Committee is directed to study the nature of legal problems which may arise from exploration of outer space. Apparently this Committee has not yet acted. The construction of a legal framework for human society in outer space does not appear to have gone forward in the UN since the preparation and filing of the report of the Ad Hoc Committee discussed above. It is hoped that this situation will not continue too long.

In September 1960, in his address to the UN General Assembly, President Eisenhower warned the world, saying: "Another problem confronting us involves outer space. The emergence of this new world poses a vital issue: Will outer space be preserved for peaceful use and developed for the benefit of all mankind? Or will it become another focus for the arms race—and thus an area of dangerous and sterile competition? The choice is urgent."

If this solemn warning is not heeded, the world may fail in the great project of expanding successfully our earthbound social structure into outer space. ♦♦

TOUGH NUT?

TAKE YOUR MATERIAL PROBLEMS TO 3M MISSILE INDUSTRY LIAISON

3M's Missile Industry Liaison is the one-stop Information Center for the missile and design engineer. Staffed by technical personnel experienced in rocket propulsion and other phases of "missilery," it makes a definite point of knowing "who's doing what" in 3M. Whether you are concerned with a specific product application or a general field of activity, MIL is well qualified to translate your problems to those 3M specialists in your field of interest. Let MIL serve as your guide to 3M Divisions and staff laboratories.

3M PRODUCTS FOR THE AEROSPACE INDUSTRY

Adhesives and Sealers
Ceramics and Refractories
Coated Abrasives
Coated Fabrics
Data Duplicating and Handling Systems

Elastomers, Plastics and Resins
Electrical Insulation
Fluorinated Fluids

Instrumentation Tape Recorders and Magnetic Tapes
Metal Finishing and Treating Materials
Non-Skid Surface Films

Radioactive Materials
Packaging and Protective Films, Papers
Potting, Encapsulating and Impregnating Compounds

Printed Circuitry Materials
Reflective Films and Fabrics
Reinforced Plastics

Specialty Tapes
Surface Markings
Thermal Insulation
Thermo-Electric Components

For further information, write: MIL Group, 3M Company, 900 Bush Ave., St. Paul 6, Minn.

Please send me:

☐ a copy of the brochure "Products for the Aerospace Age."

☐ the bi-monthly "Materials Memo" bulletin.

NAME____________________

FIRM____________________

ADDRESS____________________

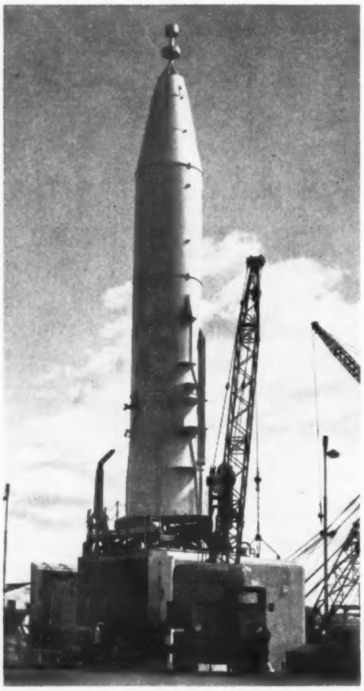
CITY__________ STATE__________

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Key number 31

"A Stitch in time . . ." For Silo Launch



This water-ballasted iron dummy of Atlas, constructed for the Air Force by Convair-Astronautics, stands on the launch platform of an experimental underground silo at Vandenberg AFB, Calif., where it takes part in checkouts of such equipment as the elevator system that will raise and lower the operational missile. The dummy has the same dimensions and water-ballasted weight as the new Series-F Atlas.

Economic Impact

(CONTINUED FROM PAGE 57)

At a minimum, the result will be expanded telephone, radio, and possibly television networks. The side effects are beyond measure. With faster, cheaper national and international communication links, companies everywhere will be further encouraged to go after foreign markets. Also, what would be the effect on world trade, for instance, of opening this new worldwide medium to our massive advertising industry? Although it is often maligned, our advertising fraternity is undoubtedly the strongest and most influential of its kind in the world. If its selling influence were beamed to foreign markets through worldwide radio and TV, the impact might be enough to tip the scale back to a favorable balance of trade for our export industry, or reduce the adverse flow of gold to a trickle. So even the man on Madison Avenue will move into the space age.

Ultimately, spacecraft will revolutionize the transportation industry at least to the extent that aircraft did in the recent past. Aircraft manufacturers are already beginning to think of boosters and launch vehicles as the trucks of space. (See page 50.) However, there is no need to look into the dim future to foresee the effect of astronautics on the economics of transportation. In the next few years, improved air traffic navigation and control devices will also be developed and these will be based in large degree on navigation satellites and radio and inertial guidance systems originally built for missiles.

As missile-pioneered techniques are applied to aircraft traffic control, congestion in the airways will be better regulated. In fact, full utilization of the airways is probably impossible without adaptation of spacecraft and missile techniques.

Although it may be more than 50 years before the traveling salesman foresakes the jetliner for a spacecraft, eventually transcontinental travel may very well employ a version of the space planes now under development for the Air Force. The increased ease and speed of travel and shipping will further internationalize businesses in every field.

While these industries will receive the most obvious benefits from space developments, others will also feel the influence. The metals industry, for instance, is currently undergoing a quiet revolution equal perhaps to the development of aluminum. With spacecraft pushing into strange new environments, materials research has been forced into new frontiers. The cryogenics field alone has grown many fold just in answer to space-age demands for storing and handling of propellants used in military and space boosters. At first, materials developed will prove too expensive for common use. Later, the materials of astronautics may be put to work in consumer products such as the automobile and even in the family pots and pans.

Also, throughout the manufacturing world a new level of product refinement will result from the exacting demands of astronautics. The missile and space field has introduced a new degree of super-accuracy in manufacturing processes. For example, during World War II, gyros were generally acceptable if their drift rates were of the order of 10 deg per hr. In the 10 years following the war, gyros were developed with drift rates of 0.10 deg per hr. Gyros in the development stage today are expected to have rates as small as 0.0001 deg per hr when perfected.

The cleanliness requirements in an advanced missile plant today indicate the new level of product refinement expected in the space age. Foreign matter weighing as little as 75 microns must be removed from the missile to assure a successful flight. As engineers and production workers trained in the aeronautics and astronautics industries filter into other fields, they will take along their high standards. The result will be more reliable, longer-lasting industrial and consumer products such as machine tools, outboard motors, kitchen equipment, and television sets. Without knowing it, consumers will profit as an indirect result of the tax dollars they invested in precision training of space industry employes.

Upheaval, Not Utopia

However, astronautics will not bring forth an economic utopia automatically. It promises only an upheaval. And, even though the benefits might be untold, as with every force that shakes a society, the forces of astronautics will leave casualties. The billions in taxes might not be the only price we will pay.

For instance, astronautics does not offer a rapid solution to unemployment—a solution we might normally expect from a $2-billion annual budget for a national program. This opinion is soundly based on an analysis of the recent employment record in the industry. The Aerospace Industries Assn. reports that there were less than 640,000 employes in the industry in September 1960, down a quarter of a million since the postwar employment peak of 1957. This decline is caused principally by the shift from mass production of aircraft to precision fabrication of very limited quantities of missiles and spacecraft.

To complicate the problem, present unemployment rolls are dominated by unskilled labor, yet the growing space field provides little opportunity for the untrained. Many plants today have one engineer for each production worker. Even the man at the machine must keep abreast of fast-moving technology to retain his job. As sophisticated techniques and products are absorbed into other industries, the demands for technically-oriented employes will also become more acute.

Automation, too, will receive a boost from space experimentation. For early space flights, engineers have eliminated the need for a pilot. The mechanisms that substitute for a space pilot will later be used to replace men at many machines on the ground. The result will be a further mushrooming

of automation, again decreasing the need for unskilled labor.

Whether the influence on the economy is favorable or not depends largely upon the nation's willingness and ability to retrain its people. For millions of individuals, the space age could become a financially bleak era if they enter it ill-prepared to participate. At the same time, high-paying opportunities will increase for technically trained men and women as the impact of the space program is felt throughout the economy.

An indication of how far we have yet to go in technical training of personnel is indicated by the fact that only an estimated 15,000 people graduate from our engineering schools each year. Because no adequate basis for comparison exists, it is difficult to compare the educational "gross national product" of the U.S. with that of the Soviet Union taking into account the over-all quality, scope, and requirements in the various disciplines. We do know, however, that in Russia a massive effort is in progress to provide technically trained men and women, and that a national awareness of the great need exists. A more graphic example of the problem can be seen by glancing at the help-wanted sections in any metropolitan newspaper. Columns of ads are aimed at recruiting engineers, scientists, and technicians. The shortage of trained people can be punishing both to our space program and to our economy.

Labor, however, is not the only group to feel the conflicting pressures of the space-age upheaval. Capital, too, will continue to face a challenging mixture of business opportunity and profit-squeezing in the new era. Despite the billions of government dollars being directed toward the aerospace industry, only the best-managed companies will make a reasonable profit in the next 10 years. The reason is the rapid, penalizing pace at which missile and spacecraft orders have replaced the major portion of aircraft purchases.

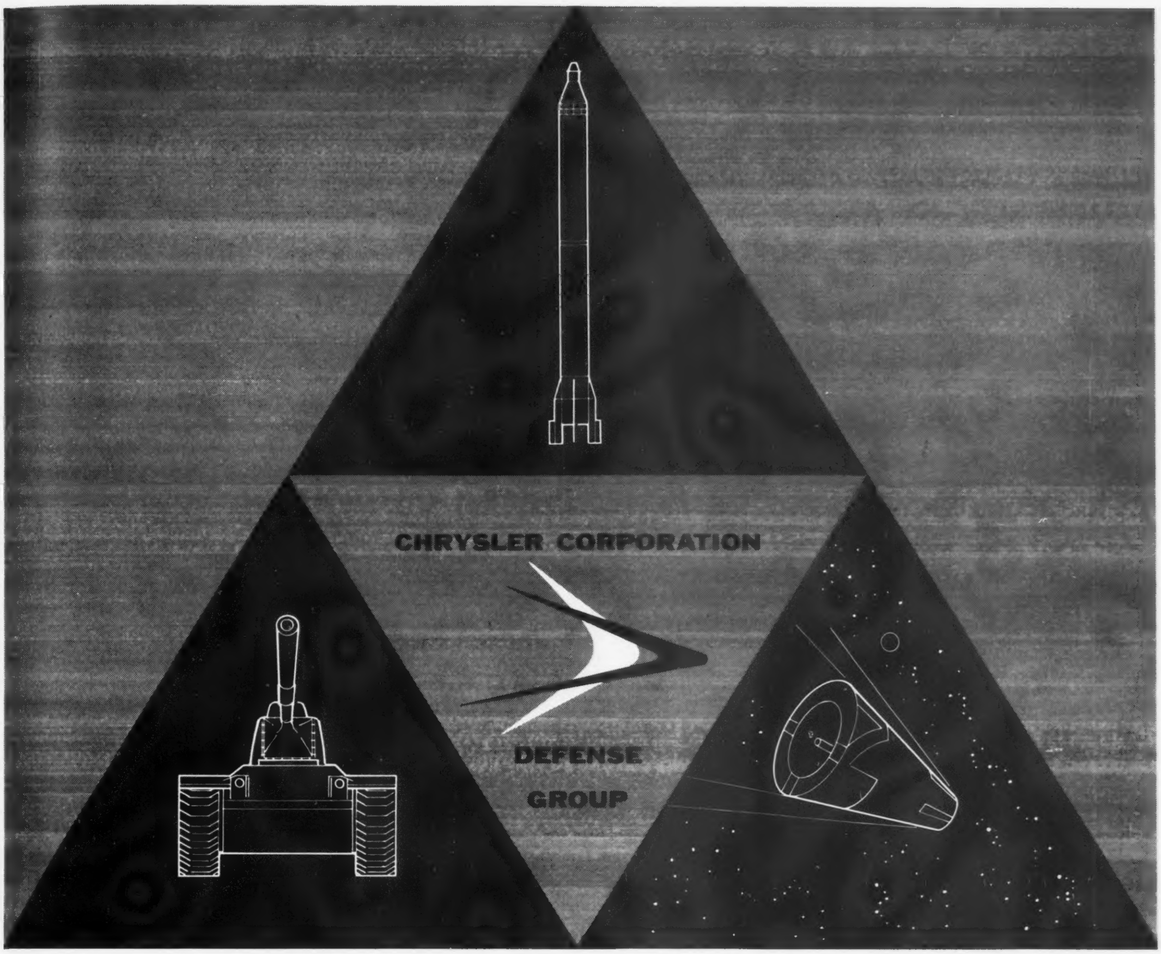
Because of the small production runs for missiles, production plant requirements have been cut in half in the last three years, and may be cut another 50% in the next three years. Nevertheless, business has not been allowed to retrench by using old facilities. In spite of the decrease in over-all plant requirements, the industry has had to acquire an estimated $2 billion in new facilities in the past five years to keep up to date. Even the nature of the facilities has changed. Gone are the long production lines of World War II; in their place are modern laboratory and plant structures with a combination college-and-factory atmosphere to house the new technological teams.

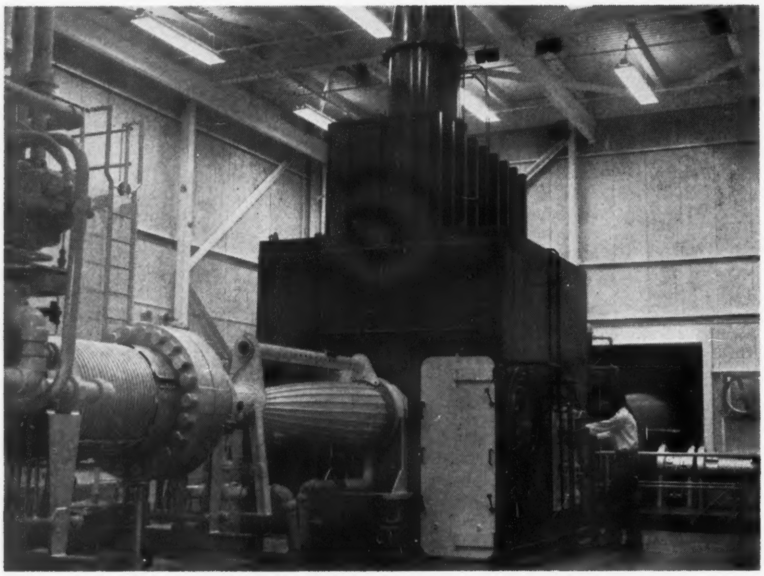
Tight Profit Picture

The result of the demands for new facilities has been a tight profit picture at a time when the industry has a massive peacetime backlog of $12.5 billion in orders. Yet company management in most instances anticipated the problems, knowing that no new industry can be born without a few labor pains, and that future rewards make the problems worth solving.

The same is true of the total impact of the space age on our society. A few, particularly those who hang on to the past for too long, will suffer. Just as the automobile hurt the carriage maker's business, the products of astronautics will replace or alter many of the companies and products we know today. But out of the upheaval can come a better world.

Then, 50 years from today, you will find our advanced, sophisticated, complex products of 1961 only in a museum. ♦♦


CHRYSLER CORPORATION
DEFENSE
GROUP



New Douglas Wind Tunnel in Operation

First view of new hypersonic wind tunnel in operation at Douglas Aerophysics Lab adjacent to the firm's El Segundo Div. Said to be the largest of its kind in the country, the tunnel, capable of testing models up to 36 in. long and 6 in. in diam at speeds up to Mach 10, was completed in three years at a cost of $2 million.

Communications

(CONTINUED FROM PAGE 53)

required to make possible practical systems designs characterized by reliability and economical costs, and to provide the measurements and transmitted signals, the information storage and handling, and the over-all world control of everything important that moves without using too much of a limited frequency spectrum and without interference with other communications needs.

Weather Control Needs

Weather prediction and, ultimately, weather influence and control also will demand new communications resources of the world. Advances will be required in basic meteorology and in some aspects of astrophysics and nuclear physics. However, any effort to provide detailed, over-all predictions of weather so as to influence world operations advantageously, even aside from ultimately tailoring the weather to improve the use of the world's surface and enhance the efficiency of the world's operations, will require substantial expansion in communications methods and facilities. Observations will have to be made simultaneously at many points on the earth's surface, in the atmosphere above, and in the space substantially farther out. These collected data must be brought back to central points for processing together with stored data of the past in accordance with prediction formulas that will have to be worked out. These results, in turn, will have to be sent to decision centers, either automatic or involving high-level human participation. The huge array of final controlling actions will have to be communicated to numerous points on the earth, in the atmosphere, and in space where equipment, under precise control from a distance, will supply matter or generate radiation in an effort to influence the weather. The equipment everywhere will all the while have to be under instantaneous monitorship, tied in to a large and complex worldwide communications net for this purpose.

Obviously, a severe problem in the space age will result from the potential overcrowding and saturation of the frequency spectrum. Technological advances in information theory, new methods for assembling a message into electromagnetic waves, and new means for control of the generation and modulation of electromagnetic waves over the entire spectrum will do much to condense messages so as to use the minimum of space in the spectrum. Added precision, resting ultimately on better understanding of the fundamental nature of radiation from physical matter, will enhance the chances of success here. However, fuller utilization of the entire spectrum—from the lowest electromagnetic frequencies through heat, light, X-rays, cosmic rays, and fundamental particle beams—will probably characterize space-age communications as the years pass. Without such advances, we can easily find the world in a chaotic new kind of cold war over control of the frequency spectrum, with each autonomous nation or group seeking to get its message through by outshouting the others in a growing signal-power-generation contest.

Out to Three Dimensions

These facets of the world's growth are largely concerned with communications to insure the operations of our two-dimensional, earthbound civilization, with space technology used only to provide new and additional means for coping with these problems. In addition, space opens up new fields of its own, with both problems and potentials, as space exploration and space research move us more into a three-dimensional civilization. As man seeks to visit, understand, and occupy all of the space around the earth, the moon, and the nearby planets, and perhaps even beyond, he will encounter new problems of communication time delays, vast distances, new orders of magnitude as to directivities, power requirements, minuteness of received signals, peculiar doppler effects, electronic equipment exposed to uncharted radiation conditions, subminiaturization and low-power-consumption requirements—a vast horizon of new conditions, new challenges, and new possibilities. Because the environment of space is so greatly different, because the numbers that characterize the main communication parameters are grossly different from those we are accustomed to in dealing with earth communications, we can expect entirely different techniques of communications to be invented.

Thus space is a source of solutions for the communications problems of our earth civilization. It is also a source of new discoveries and problems, a region of endeavor, and an epoch in the history of communication science entirely different from the past. ♦♦

Power in the Space Age

(CONTINUED FROM PAGE 55)

atmosphere has stimulated a variety of researches which have added considerably to our fundamental knowledge of high-temperature gases. Thus to understand the re-entry problem, it has been necessary to make detailed studies of the chemistry of the components of air at temperatures ranging up to levels at which it is completely dissociated and ionized to a substantial degree. It has been necessary to measure many important reaction rates and to measure and understand many of the collision phenomena which occur in such gases. It has been necessary to evaluate many transition probabilities for the emission of radiation by molecules and atoms in excited states. To be able to communicate with re-entering objects, it has been necessary to perform a great deal of research on the reactions producing ionization and on the collision processes of electrons with other species. It has been necessary to make detailed studies of the fluid mechanics of reacting gases. Thus in the past few years the tremendous increase of our knowledge of molecular gases in the temperature range up to 20,000 K has been obtained in providing the scientific basis for re-entry into the atmosphere. This knowledge is now contributing to the development of the MHD generator.

Before the advent of space flight our only knowledge of the interplanetary plasma was based on its indirect influences on the earth's magnetic field, whistlers, cosmic rays, etc. The advent of instrumented space vehicles has made it possible to probe the interplanetary plasma and the plasma trapped in the earth's magnetic field in great detail. The radiation hazard in space flight provides a tremendous impetus for the study of these plasmas. A great deal remains to be done in this field, and it is abundantly clear that direct probing by space vehicles will provide much fundamental information about the dynamics of plasmas.

It must be remembered that almost all of the material of the known universe is in the form of highly ionized plasma. The earliest impetus to the study of MHD came from attempts to understand astrophysical phenomena. The discovery of plasma containment by the earth's magnetic field as experienced in the Van Allen Belts was a tremendous stimulus to laboratory attempts to contain high-temperature plasmas in magnetic fields. The sudden commencement of magnetic storms has been attributed to shock waves in the interplanetary plasma, and these shock waves have now been correlated with laboratory experiments and have led to some understanding of dissipation phenomena in high-temperature plasma. The spectacular violence of the disturbed solar atmosphere provides one of the best visualizations of the phenomena of plasma dynamics. The continued efforts of astrophysicists to understand disturbances in the sun's atmosphere will play a great role in our understanding of the interplanetary plasma and plasma dynamics generally.

The propulsion of space vehicles with chemical rockets requires the expenditure of masses of propellant many times larger than that of the vehicle. One of the best opportunities for reducing the costs of space flights lies in the electrical acceleration of plasmas to produce jets with velocities comparable with or somewhat larger than the vehicle velocities. In this case, the mass of propellant will not be large compared to that of the vehicle. Two elements are required for the achievement of electrical propulsion. The first is a thrust chamber which will convert electrical energy to kinetic energy of plasma with velocities of several tens of kilometers per second (specific impulse of several thousand seconds). Such devices have been under exploratory development for several years, and it now seems likely that a number of them will achieve the desired specific impulse with satisfactory efficiency.

Light Generator Required

The second element required is an extremely light generator of electrical energy. The weight of conventional electric power machinery or solar cells driven by solar or nuclear energy can result in electrical propulsion systems having some advantage over chemical propulsion. However, the great advantages anticipated from electrical propulsion will require the achievement of electrical powerplants with greatly increased power per unit weight. It seems probable that such great advances will be forthcoming from the combination of a fission reactor with an MHD generator. For example, calculations indicate that, if a cavity reactor is combined with an MHD generator, an electrical propulsion system is conceivable which can take off from the ground with specific impulses exceeding 1000 sec. Such a propulsion system would lead to really spectacular advances in space flight.

In conclusion, the great current enthusiasm for magnetohydrodynamics stems from its close relationship both to nuclear energy and space flight. It draws strength from both of these areas, and information learned in the

one area readily contributes to the other. It seems now that both large-scale space flight and abundant nuclear energy will profit greatly from the second wave of interest in plamas which was stimulated by them. It also seems likely that magnetohydrodynamics will be one of great links whereby research and development directed toward space flight will result in increased abundance on earth. If we attempt to foresee now the mechanism whereby the order of magnitude increases, forecast as the energy revolution, will be handled, it seems most likely that MHD will play a dominant role. ♦♦

Social Psychologist's View

(CONTINUED FROM PAGE 61)

impress (in one way or another), and thereby distort the goals of our space program and the values on which it is presumably, if vaguely, based.

A related rationale for space activities, also masquerading as a substantiated state of affairs, has to do with American public opinion regarding astronautics. In high places and low, within and without the space community, people pontificate gratuitously on the state of public opinion, ignorantly equate the attention given in the mass media with the interest of the public, and forget that the District of Columbia, Cape Canaveral, and Southern California are not the United States. So, we have insistent claims that the American public is strongly in favor of an all-out space program, that the American public appreciates the nature and challenges of the space program. Of course, some feel that this attitude is not demonstrable at the moment, but rather that it lies nascent in the bosoms of Americans, waiting to leap into frenetic life if someone will only provide our citizens with the true facts regarding the implications of astronautics.

These assertions can hardly be based on up-to-date data on American attitudes about space. There aren't any. And what facts there are, from earlier studies, either run counter to this image of massive public support or the results are ambiguous and thereby make it difficult indeed to interpret the meaning of the data that are available. If astronautics is to help our civilization into a bright new future, judgments about the public perception of it and involvement in it will have to be based on more than dull old mythologies about the public and its interests. We have yet to use what all studies on the nature of public opinion verify: When it looks at all,

the general public sees new horizons through old eyes. Most of the time, and for most people, traditional goals and day-to-day preoccupation are the subjects of their true interests. Astronautics is neither a traditional nor daily preoccupation.

Military astronautics has received a share of enthusiastic speculation. Those responsible (as well as others, to be sure!) talk about and plan military systems of orbiting weapons and military lunar launching sites as if these things could be realized as weapon systems (rather than as experiments) in a time period when world power is likely to be distributed as today and the motives of nations are likely to be as they are now. But all indications are that the world must move toward internationalism if it is to survive and be effective politically and economically. And all indications are that the pressures of social change, population growth, and massive automation will force other basic shifts in national values and patterns of behavior. Yet, out of too simple-minded an approach to tomorrow or out of positions motivated by expedience, we argue for and present the image of astronautic military systems two to three decades from now as operating in the same kind of political world as exists today.

Similarly, we look at space colonization as an aspiration and activity that will be guided by present political perspectives, national aspirations, and raw-product needs. But colonization too, on a substantial scale significant for these goals, is many years off and subject to the same shifts in perspective just mentioned. The implications are so vast that they make parochial images based on present national aspirations pathetic—indeed ridiculous. For instance, really extensive colonization may very well depend on fusion power to provide economic booster wherewithal for such missions. But fusion power for space means fusion power for earth, and this implies an unprecedented historical situation where all nations can have all the power they need. Can one really imagine mining the moon and then shipping the products to earth when nuclear power would permit extracting all the metals we would need from the oceans and sophisticated chemistry would bring the manufacture of tailor-made materials of all sorts? Might it not be more realistic and imaginative to begin now to develop in our own minds and in the minds of those outside the space community the merits and requirements of non-national space colonies? One suspects that this perspective would provide many new incentives here and abroad for rational and enthusiastic planning as well as for dampening inappropriate chauvinism.

We might also be more candid and imaginative in viewing our present space operations. We talk about free enterprise's stake in space activities, when at the same time most of the financial support for space programs is on a cost-plus-fixed-fee basis, which is another way of saying that the government essentially subsidizes industry in these areas. And isn't it true that often the next contract goes to the company that most needs the financial assistance, rather than necessarily to the company with the best proposal? On the other hand, the government frequently expects free enterprise to forego one of its strongest bases for new profits and to share with others its new ideas developed even partially on government funds.

The whole idea of government and free enterprise as distinct entities with differing missions is so inadequate to the needs of astronautics as to require radical revision. (For example, the pattern of industry-government arrangements in connection with the development and ownership of satellite communications is quite inadequate, in the light of the national and international operational problems these satellites will eventually present —aside from who gets the telephone revenues.) Nevertheless, so far both government and industry persist in their traditional views of the right way for them to operate, and so far neither institution encourages the efficient but radical revision in institutional arrangements required.

Manpower an Issue

While enterprise doesn't seem to be free either to make the profits or to rise or fall on the basis of the quality of its product, it is free, however, to stockpile crucial creative manpower on a sometimes irresponsible and, indeed, irrational scale. These stables of engineers and scientists, to be sure, do help astronautics evolve, but partly too they exist at the level they do simply to provide corporations with the image of *having* such a capability when the next contract opportunity arises. In the minds of many observers there is a profound question whether industry and the nation are not jeopardizing the future, not only of astronautics but of other crucial socially and scientifically imperative programs, by depleting the numbers of teachers and research personnel in the universities through the attractions of high salaries and extensive laboratories that industry provides. Certainly, here is one area where efficient allocation of re-

Key number 39

sources is crucial to the future of the nation as well as to astronautics. But traditional perspectives erode even our will to learn the facts, much less to revise our modes of operation.

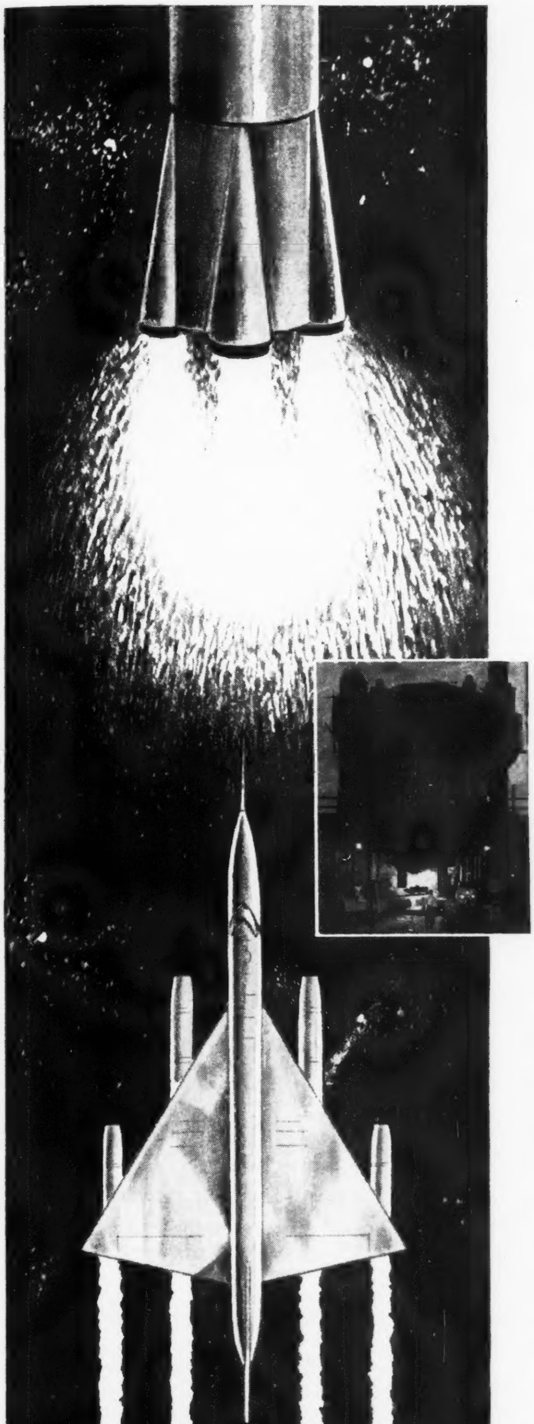
When forced to acknowledge the slipshod basis for our justifications of astronautics and the style in which we pursue it, many find comfort in one more retreat from the responsibilities of reality by appealing to history as a rationale for our chaotic approach to the future. But the history they appeal to, for arguing the inevitable merits of a planless concentration of engineering and intellectual effort, is a mythological history. It is claimed that Columbus' effort was a shot in the dark and an investment in basic research. It is claimed that the seers did not or could not contemplate the future of the airplane when it was invented. These myths have been peddled so long and are so useful that many who are otherwise critical of facts, and authorities, accept them, even though any good encyclopedia will reveal that the historical evidence is quite to the contrary.

Planning Well Is Possible

But, even if these mythologies were true, it doesn't for a moment follow that now we have equally little capacity to look ahead and recognize the possibilities and problems of astronautics. Not only have we developed such powerful techniques as systems analysis and operations research, but now, as never in the past, there is a premium on poetic and unbridled imagination. One might very well speculate that any ideas we haven't thought of regarding the future of astronautics are so extreme that, were they to be realized, it could only be in a social context so different from what exists today that it would not be meaningful to speculate on these efforts in terms of today's values and aspirations!

Through the use of fancies of history, rather than the facts about the past and present, we see a further example of men trying to apply a traditional style of implementation to this most radical invention called astronautics.

On a "higher" level of motivation, there is much talk in astronautical circles about the need to make scientific progress in space as fast as possible, and that this search for scientific truth as such is a major reason for all-out space activities. Yet throughout all of the pontificating about the pursuit of science, there is an endemic and, one suspects, often deliberate and dangerous appropriation to science of the different functions and goals of technology and the different values and motives of technologists. At the



GR6X

Forging a metal spectrum for any flight environment

Whether design criteria be Mach 2 or escape velocity — the part a wing spar or rocket motor nozzle — most of the significant advances in forging conventional, exotic and refractory materials come from Wyman-Gordon. Here, technical breakthroughs in size, complexity and strength-to-weight ratios of forged airframe hardware and propulsion components have materially raised performance ceilings for every type of vehicle — global bomber to deep space probe capsule. Always impatient with state-of-the-art concepts, Wyman-Gordon engineers and metallurgists constantly explore ways to bring hitherto "unforgeable" metals and alloys into operational use — broadening the spectrum of ultimate-performance materials available for advanced vehicle designs. Consultation on your project requirements can help achieve better correlation of materials to service environment.

CURRENTLY FORGING THESE AERO-SPACE MATERIALS

Aluminum	Beryllium
Titanium	Molybdenum
Magnesium	Tantalum
Columbium	Zirconium
Hafnium	Tungsten
Inco 718	René 41
Astroloy	Waspaloy
Stainless steels	Vacuum-melt alloys
Nickel-base alloys	Iron-base, high-temperature alloys
High-strength die steels	20-27 Nickel steels

VISIT OUR EXHIBIT
BOOTH 252
AMERICAN ROCKET SOCIETY'S
"Space Flight Report to The Nation"
NEW YORK COLISEUM
OCTOBER 9-15

EST. 1883

WYMAN - GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS · WORCESTER MASSACHUSETTS · DETROIT MICHIGAN
GRAFTON MASSACHUSETTS · LOS ANGELES CALIFORNIA · PALO ALTO CALIFORNIA · FORT WORTH TEXAS

Key number 41

same time, as almost all of us know privately, many scientists object to the extreme attention and allocation of resources provided to or claimed by astronautics—even scientific astronautics. Many in the astronautics community privately feel that, in fact, if the USSR curtailed its space program, we would curtail ours—the call of science notwithstanding. And certainly it's evident that the military services, various agencies, and ambitious individuals have simply used the rallying cry of scientific progress as a stone on which to sharpen their private axes.

Ethical Transfer?

Related to the pursuit-of-knowledge argument is the almost ironic one which urges ever greater astronautical efforts on the grounds that the glamour of space makes the activities and values of science and engineering attractive standards of conduct. Thereby, astronautics should benefit society by increasing the proportion of rational, imaginative, and honest people in the population at large. But, rather than expanding man's perspectives, our approach to astronautics is deplorably lacking in the kind of rational social imagination and versatility necessary to integrate astronautics worthily with the rest of the world in which it will operate. Rather than enlarging our imagination, we spin astronautical fantasies based on parochial perspectives and old wives' tales about the nature of man, society, and technologies.

As for honesty, what should we say, for example, about the motives and values of scientists who support the lunar man-in-space program, even though they don't believe in it, because they believe this is the only way to get support for their favorite studies? It is a corrupting situation indeed when we try to sell ourselves and others on the virtures of scientific values by distorting scientific opinion and motives regarding astronautical activities.

Rather than eliciting new and exciting motives and aspirations—to say nothing of rationality, imagination, and honesty—space is being promoted just like next year's car this year, and for many of the same reasons. Public-relations releases are presented to and treated by the mass media as news; that is, as facts. The future is invariably imminent; discussion of the inevitable delaying failures to be expected in any program is avoided; and "no technological breakthroughs" are required for the most grandiose of contemplated astronautical feats. Technological progress in space is always equated with the common good. But since some people are clear-eyed enough to reject this assertion, it is also argued that knowledge is neutral and only man's use of it is good or bad.

In the midst of all this promotional fanfare, we blandly ignore that the *motives* and means for accumulating knowledge or pursuing technology always contain the seeds of good or bad. This is especially so since today's scientists, engineers, and their promoter-spokesmen strongly influence the social environment for astronautics, by the very methods by which they pursue its goals. When these motives are shallow or hypocritical, the social products will very likely be shallow and misleading, with frustrating and unpleasant consequences.

In summary, this social psychologist sees today's conduct of astronautics as a particularly spectacular symptom of our growing chronic cultural incapacity to marshall effectively the resources and powers the culture has produced. We have put the good fairy who is supposed to solve all our problems in a spacesuit; but, so far, at least, we humans have been inadequate to the social and ethical challenges of space. We have for the most part left the public and programmatic meanings of astronautics to our cultural blindnesses, hypocrisies, and prejudices.

For many reasons this may be all we can do, because societies which have been successful grow from their traditions rather than from revolutions, and because it is in the nature of men to try to hold tenaciously to forms of behavior which have been successful in the past.

A Search for Truth

Still, perhaps through knowledge of *facts* about ourselves and society we will stand some slightly better chance of implementing a better philosophy for astronautics. Self-knowledge is always useful. It is especially useful when so many of those directly and indirectly involved are subject to the special seductions of pseudo-reality encouraged by wishful thinking and public relations about astronautics. We must recognize the properties and processes of the pseudo-reality in which we're operating and the pitfalls it holds.

We must recognize that by so operating the chances are slim indeed that astronautics will be able to fulfill its potential for broadening and enhancing man's activities and his view of himself. ♦♦

ULTRAVIOLET COMMUNICATION SYSTEM FOR SPACE

Westinghouse scientists are developing a new kind of space communication system. Called Ultracom, it will use a beam of ultraviolet light, modulated to convey information.

In a space vehicle, the electrical supply and volume are limited. Here Ultracom will have many advantages over radio. Because UV frequencies are higher than radio—about a million times—signals are disturbance free and can be sent farther with less power: 50 million miles, for example, with a radiated power of 1 watt. Ultracom will require far less area for antennas, and reliability will be high because of equipment simplicity.

Westinghouse scientists were the first to achieve communications by ultraviolet. Development of the Ultracom system for space application is another example of how Westinghouse is *First* with the Future. Defense Products Group, 1000 Connecticut Avenue, N.W., Washington 6, D. C.

Key number 43

Westinghouse

J-02332

Notice To Attendees Of The SPACE FLIGHT REPORT TO THE NATION

Attendees returning from the SPACE FLIGHT REPORT TO THE NATION by plane should plan their departure time so as to avoid the nationwide postponement of all air travel during the Air Force exercise, Operation Skyshield, to be held on Saturday, October 14, from 1:00 PM, Eastern Daylight Saving Time, until 1:00 AM, Sunday, October 15.

The exercise will begin at the same instant throughout the nation. Therefore, the starting time should be moved back for the Central Standard, Mountain Standard, and Pacific Standard time zones.

Only air travel will be affected by the exercise.

Space-Age Education

(CONTINUED FROM PAGE 45)

bridges, machines, airplanes, missiles—what we in the space-aeronautical industry call "hardware." And his primary purpose is creating hardware, so we should not underestimate his faculty and his talent for design. Unfortunately, I believe that talent for design is more or less something you bring with you, although you can develop it and you can improve it. It is something one must be born with.

Today, we cannot design by intuition alone. The engineering student, in addition to his ability to design something, must also understand the fundamentals of natural science. And I believe that if he wants to become an executive, if he is interested in sales, or interested in administrative problems, he should also understand the fundamentals of the social sciences. I think this is very important.

A lack of fundamental grounding in natural science has sometimes been rather serious in civil engineering and, also, I would say, in mechanical engineering. The aeronautical engineer has been in a somewhat better position, because aeronautical engineering and aeronautical science started almost at the same time, and developed in parallel.

In 1953, we celebrated the fiftieth anniversary of the first flight. In aeronautical science, Professor Prandtl, who was also my teacher in Germany, presented the concept of the boundary layer in 1904. And so, almost at the same time flight became a practical reality, and within 10 years of the time when it started to become an industry, the ideas necessary to understand such things as frictional resistance, stall, separation, and so on—fundamental problems in aeronautical engineering—were developed into a science. Also, we must recognize that the main chapters of supersonic aerodynamics were already developed before the sound barrier was broken.

Thus, the aeronautical-engineering student is in a very fortunate position, because he can follow technical progress and the progress of science at the same time. There is one great difficulty, however, in aeronautical engineering. The field is becoming larger and larger. When we started aerodynamics, we could consider air to be an incompressible fluid like water, and this approximation facilitated the solution of many practical problems.

Ascent of Thermodynamics

Then, as the velocities increased and we came into the transonic region, consideration of thermodynamics became necessary.

I remember the time when the so-called compressibility effect started to play a role in airplane design. I was invited to one of the large airplane companies in California. They had terrible vibrations in a wing, and the "flutter" man said, "This is flutter." I looked at the records and the design a little and told him: "I am sorry, but this has nothing to do with flutter. These are shock waves." Later, they made Schlieren photographs of the flow at the wings and the shocks were there. So our science became much more complicated, with thermodynamics playing an important role.

Fortunately, at the time, we did not need chemistry, for most of the engine companies had chemists, specialists who knew about "anti-knock," and that was sufficient! But after the piston engine was replaced by the jet, this method did not work any more, because you could no longer separate flow phenomena from the chemical process of combustion. As hypersonic velocities come into the picture with missiles, you also get chemical reactions that you don't want. After all, if you want to burn kerosene, the chemical reaction is something you definitely want to plan for. But if you have a missile and it enters the dense atmosphere, you have high-temperature dissociation and re-combination—you have reactions which you don't want. Nature produces them and you have to understand them.

New Word on Scene

I proposed the name for that: "Aerothermochemistry." The word "aerothermodynamics" was proposed by an Italian pioneer in aerodynamics, General Arturo Gaetano Crocco. After that I said, "Now we have not only aerothermodynamics but aerothermochemistry." I was very much amused that a Western university held a symposium on "Aerothermochemistry" three or four months later.

As we become interested in space flight and new methods of propulsion, it turns out that even chemistry is not enough. We need electromagnetism. There are many educational and industrial research centers where this new branch of aerodynamics—what is generally called "magnetohydrodynamics"—is successfully cultivated.

I should add that I am against this name because, for me, "hydro" has something to do with water. It should be "magnetofluiddynamics," or better still, "magnetofluidmechanics." I hope the denomination "magnetofluiddynamics" will be generally accepted some day.

So you see the aeronautical engineer of today must be interested in all these neighboring sciences—not only physics, thermodynamics, and mechanics, but also chemistry and electromagnetic theory.

The word "space" created something of a panic, I would say, in industry, and perhaps also in science. However, I don't think we should say that aeronautical science is ended now that aerospace science has started. It is to me only an extension, for I consider that the new name means we have new ideas of speed limits and new ideas of high altitude.

So I do not believe there is any reason to say that aerodynamics is obsolete. There is no reason to say: "I am an airplane designer: What shall I do? Nobody wants airplanes."

First, for some years yet we'll need airplanes for flight within the atmosphere. Second, the problems which we had in airplane design we also have in missile and spacecraft design. It would be a miracle if we could produce vehicles for space or vehicles for

the upper atmosphere and not have the same problems—buckling, flutter, and so on—that we had in airplane design.

Chemistry and electromagnetic theory are especially important to the engineer who works on problems of astronautics. I have no need to explain to the rocket engineer that chemical kinetics is perhaps the most important science he has to study. Problems of stability and instability of combustion in rocket chambers are perfect examples of problems in aerothermochemistry.

There are several other reasons why chemistry and electromagnetic theory should be studied. First, the medium in which the spacecraft moves may be subjected to chemical changes and the spacecraft itself may be influenced by electric and magnetic fields. Second, the design of spacecraft or satellites must depend on how electromagnetic waves should conform when reflected from the spacecraft. Not only the specialist, the radar engineer, but also the designer must be familiar with electromagnetic waves. Finally, magnetofluiddynamics and plasma physics opened a quite new branch of propulsion theory and propulsion design for space. I understand that courses in this new branch of propulsion are already being given at several engineering colleges.

Thus I believe that, on the one side, the continuity of the engineering profession and engineering education can be preserved. On the other side, however, an honest and competent effort is necessary to adapt engineering education to the new age. ♦♦

Military Impact

(CONTINUED FROM PAGE 49)

undertakings of this sort on a very large scale, and a time at which space technology will have been chosen as one of the more important areas of competition between the United States and Russia.

It is probably unnecessary to discuss the impact of astronautics upon our present military posture in much detail. A great many articles, and even books, to say nothing of countless classified studies and reports, treat this subject in great detail. Congressional committees continue to deal with the relative importance and suitability of missiles compared with other kinds of strategic delivery systems, and of one type of missile system with respect to another as part of an on-going consideration, and even debate which is of interest in many circles throughout the nation and, in fact, the world.

Perhaps one of the most curious features of the literature and the discussion concerning ballistic missiles is their great psychological importance. Probably never before have people generally been so much concerned by a few weapons. Perhaps never before has so much forward planning and so many programs and expenditures been undertaken because of a particular weapon which a nation thought another had or might have. We have faced situations before where potential enemies owned millions of rifles, thousands of armored vehicles, tens of thousands of airplanes, but we have never before exhibited the national awareness and the national concern or the national effort that has been brought forth in recent years by the possibility—indeed the likelihood—that the Soviet Union would develop and deploy ICBM's carrying nuclear warheads.

All this is a measure not only of the military impact but of the unique qualities and psychological and political impact of the ICBM and the IRBM. No single weapon has ever before had a corresponding impact; and although it is really the thermonuclear bomb at the end of the missile that does the damage and comprises the threat, these delivery systems have altered the strategic equation and created new problems and new technical challenges in an unprecedented way.

This then raises an interesting and much debated question: What is more effective than a ballistic missile as far as space is concerned? What new weapons of ever-greater impact is space technology likely to bring forth? What will they be like? When will they come forth?

Space Weapons Limited

While there is room for different views—and many may be found—there appears to be a consensus now that the near-term prospects for new space-weapon systems surpassing the ballistic missile are not very promising. The most common proposals, of course, represent in one form or another an extension of the ballistic missile itself. They typically consist of schemes which postulate ballistic missiles which may be launched on warning and orbit the earth at least once before receiving the command to go on to target or to return to a specified recovery area, as the case might be. Another variation specifies an orbital platform from which a missile and warhead may be launched upon receipt of the appropriate signal.

These and other possibilities are unattractive now and are likely to remain so for many years, if not forever, for a variety of well-known reasons, including the following.

These proposals for "advanced systems" are aimed, in the first place, at improving invulnerability, which we seek now through hardening, dispersal, mobility, or combinations of these. It is both cheaper and simple to attain invulnerability or to diminish vulnerability by these means than by the more glamorous but less practical orbital approaches.

And, of course, reliability is not everything it might be in the ballistic-missile field, nor in many others, including electronics and communications; nor are the prospects for great improvements in reliability as good as we would like them to be. The hazards of a misfire and the dangers of a launch in the wrong direction or at the wrong time are both too great and too easily imagined when one thinks of missiles or bombs in orbit. For these and other reasons, such notions are advanced and considered in a probing, exploratory way, as though looking for the shaded window through which the prospect of the future lies. Not here, at least not now.

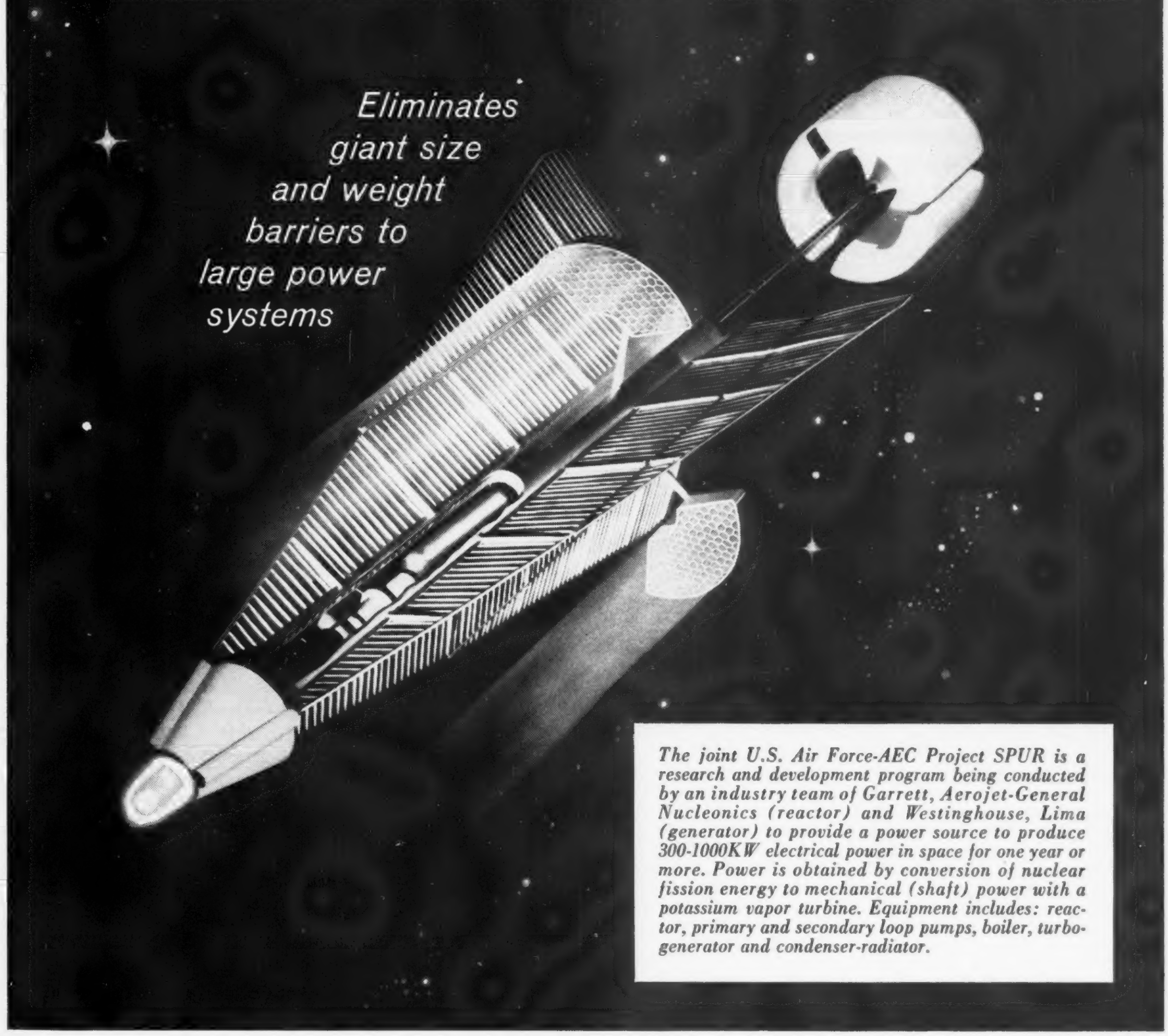
It is sometimes argued that relative to space the earth's surface, its sensible atmosphere, and its ocean depths afford comparatively little area or volume in which to hide. If you are really interested in concealing weapons of mass destruction, the argument goes, you should consider the advantages of putting them into manned orbital spacecraft a million miles from the earth. It is claimed that there they will be unseen and unseeable against the background of the stars or the brilliance of the sky by the most powerful telescopes or the most sensitive radars. They can never be detected, hence they can never be destroyed; and so they will always be available for retaliation, and serve as an even better deterrent than any mix of ballistic-missile systems and other terrestrial weapons could hope to be.

There may be some who take such proposals seriously, but there are few, if any, who would responsibly advocate that we now embark on their development. There are few, if any, who would claim now that such notions might not be superseded by more viable conceptions as the future unfolds.

In short, I believe that the great military impact of the ballistic missile will not be matched by some new

GARRETT-U.S. AIR FORCE 'SPUR'

..one answer to America's future power needs in space



The joint U.S. Air Force-AEC Project SPUR is a research and development program being conducted by an industry team of Garrett, Aerojet-General Nucleonics (reactor) and Westinghouse, Lima (generator) to provide a power source to produce 300-1000KW electrical power in space for one year or more. Power is obtained by conversion of nuclear fission energy to mechanical (shaft) power with a potassium vapor turbine. Equipment includes: reactor, primary and secondary loop pumps, boiler, turbogenerator and condenser-radiator.

Long lead time is essential to the development of large nuclear space power systems. Present methods of power generation would require an impractical heat rejection surface nearly the size of a football field for a power output of one megawatt—power which will be needed for critical space missions already in the planning stage.

Garrett's AiResearch Divisions have now completed the initial SPUR design studies and proved the project's feasibility to supply continuous accessory power and low thrust electrical propulsion in space for long periods of time.

Cutting projected 1 MW power systems to 1/10th the size and 1/5th the weight of present power systems under development will be possible because of SPUR's capability to operate at higher temperatures, thereby sharply reducing the required radiator area.

Garrett has been working with the Air Force and the Atomic Energy Commission on SPUR as the prime contractor for more than one year and has more than five years of experience in space nuclear power development. Also an industry leader in high speed rotating machinery, heat transfer equipment, metallurgy and accessory power systems, the company is developing design solutions for SPUR in these critical component system areas.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

product of space technology for a great many years. A successor to the ballistic missile is not likely to evolve for a long time. Our efforts must be concentrated more, it would seem, on perfecting the weapons we have and making fully effective the operation of new missiles and their associated equipment which our laboratories have been generating at an unprecedented rate in recent years.

We need great improvements in reliability. We need better ways to control our weapons. We need to improve our methods for training personnel and for handling the important related matters of maintenance, checkout, prelaunch preparation, and the measurement of reliability.

Many of these functions impose heavy burdens upon our scientists and engineers. It is perhaps unfortunate that many of these burdens appear often to be less interesting than dreaming about new systems or synthesizing new concepts or new designs.

It is true, nevertheless, that in the long run our greatest achievements in the field of space technology are going to be made possible because thousands of subsidiary elements are done superbly well. Subsystems and components must be designed well and must be built well. They must be tested thoroughly and they must work together not only reliably, but in a manner which enables men of ordinary intelligence and skill to operate them superbly well. The subsystems and components of importance include fuel valves, electrical relays, cables and cable connectors, push buttons, warning lights—in short, the thousands of detailed and often overlooked components which must be well-conceived and well-designed if the totality which they comprise is to answer the same description.

What Space Weapons?

Does all this mean, then, that our principal prospects for the future are confined to the perfection of existing systems? Are reliability and maintainability to become our chief occupations and preoccupations? Have we already reached the end of the line only four years after the first satellites were launched, insofar as the military impact of astronautics is concerned?

The answer to all these is "No." There are at least three areas in which astronautics will continue to have a substantial military impact, both direct and indirect. The first of these lies in the field of what is often called "supporting systems." These include systems other than the weapon systems which are important for the conduct of military operations or for the maintenance of a sound defense pos-

ture. Examples of such supporting areas include meteorology, communications, and geodesy.

All of these are of great importance from a military point of view. Space technology affords many opportunities for dramatically expanding our military capabilities in each of these fields. Communication satellites, when perfected, will not only expand the capacity and lower the cost of communicating on a global basis, but they will also afford a means for furnishing practically invulnerable communications which will be of great military importance. In fact, the advent of the ballistic missile has made the acquisition of redundant and invulnerable communications far more important than it ever was, and we are looking to space technology as an important means for achieving such capabilities in the comparatively near future. Communications satellites will have a great impact on our military posture.

Naturally, applications such as these are not limited to military use. Communications are of interest to everyone. So is meteorology.

Interdisciplinary Effects

All such applications depend heavily, of course, on the evolution of technology and techniques not only in the field of space technology, but in many other fields as well. Communication satellites will not work any better than the electronics which space technology puts in orbit. The same remarks apply to optical and electromechanical devices of many kinds used in meteorology and other support applications which are not uniquely "space" devices or techniques. All of these must be put to use in satellites of various kinds, but for the most part their reliability and suitability on the earth will be a very excellent measure, even though not an absolutely perfect one of how well they can be expected to perform above our heads in space. As these capabilities are evolved and refined, their application in space will become increasingly practical and their military impact will become increasingly important.

There are going to be, of course, enormous undertakings in astronautics not specifically aimed at military application. NASA's major program, which culminates in a manned lunar landing and return during this decade, is an example of such an undertaking. It is not intended for military purposes. It is not justified or supported by military reasons. It is supported by our Government as a viable mechanism for asserting and developing our national strength and ascendancy in the field of space technology. We are doing it because as a free nation we wish to share in this new adventure which mankind is able to undertake for the first time in human history.

There is little doubt that this great effort is going to succeed. Elements of the program will run into difficulties of course. There are bound to be disappointments, setbacks and even failures. Nevertheless, there is no doubt that our major goals will be achieved. We *will* put men on the moon and return them to the earth in a few more years!

There is no doubt, moreover, that new organizations, new technologies, new know-how will be created in the process. Perhaps even more important than whether or not a particular mission succeeds, or whether or not it is precisely on schedule, will be the permanent and long-lasting investment we will have made as a nation. The organization for getting the job done and the facilities for doing even greater jobs in the future and the technological fallout from the total effort will benefit many other areas in many ways.

It is to such "fallout," too, that we may look for important military impact. Our national technological strength will be important from a military point of view. The acceleration and evolution of space technology is likely to accelerate the perfection of devices for military use.

And it is not inconceivable, and might certainly be hoped, that these vast new undertakings in astronautics may provide a vehicle for the application of human energies, talents, and passions that would provide in part what William James 50 years ago called "the moral equivalent of war." The suggestion that the grand adventure of space exploration might furnish such a vehicle is not new. Its likelihood is not great, but neither is the likelihood that we shall see some of the more fanciful weapons imagined by today's astronautics enthusiasts.

Its impact could be far greater than any of these. ◆◆

Rocket-Missile Technology Book Offered by AIChE

The American Institute of Chemical Engineers has just published "Rocket and Missile Technology," No. 33 in its Symposium Series. Containing 10 papers on rocket technology presented at recent AIChE meetings, the 80-page, soft-cover, offset-printed book has been edited by George Szego, *Astronautics* Consulting Editor, and is available from the Institute, 25 W. 45th St., New York 36, N.Y., at a cost of $5.25 per copy.

Space-Age Transportation

(CONTINUED FROM PAGE 51)

hicles may well be only a facet of the total picture. Civil space transportation will certainly result from our current efforts. Clearly, from a minimum travel-time point of view, the ultimate mode of traveling across even as short a distance as our continent involves something similar to the current Mercury or Dynasoar systems.

Again the skeptic asks: Why pay a premium to speed across the United States in half an hour when in "conventional" supersonic transports we might do it in less than two hours? But this is the same as asking why a transcontinental passenger prefers a five-hour jet trip to yesterday's eight-hour prop flight. Our highly organized civilization has always demanded ever more rapid transport. I see no reason for this trend to disappear. The development of rapid transportation and a modern industrial society are linked in a "Which came first, the chicken or the egg?" fashion.

Civil space transportation systems, both circumterrestrial and to more distant points in our solar system, will evolve for exactly the same reasons men have always gone forth—on foot, in boats and ships, on wheels, and on wings—to seek economic gain, to find living space and to "see the other side of the hill." This is a "What is the potential market?" argument. It is well to recall, in line with our aircraft-development analogy, that United States airlines today fly a number of passenger miles equal to the total inter-city traffic by all forms of transportation at the turn of the century. And airlines have by no means totally supplanted other transportation systems—the market was simply expanded many times. As before, when man can reach New York from Los Angeles in a few minutes rather than a few hours, traffic will increase. This, then, is the important point: New vehicular systems create their own market; or, perhaps the chicken did come before the egg.

Admittedly, the extensive use of space-flight techniques which I foresee depends upon the achievement of operating costs considerably lower than those of today. To one who has watched teams of specialists during the weeks of laborious preparations currently required at a launch site prior to an actual space flight, it is indeed difficult to imagine anything analogous to present scheduled airline operations. The picture of such a vehicle landing, discharging passengers, being checked, refueled, reloaded, and launched in a few minutes seems almost inconceivable. Yet, when Wilbur Wright startled the European continent with his first public demonstration flights in 1908, he had spent weeks carefully preparing his vehicle while the Paris press called it a fraud. Surely an observer of these methodical preparations would have had equal difficulty in visualizing modern airline operations.

Basically, even the rocket-propelled boost vehicle is remarkably simple in comparison to a modern aircraft. Our currently awkward operations are a result of fragile components, not inherent complexity.

Just as turn-of-the-century aircraft projections were inhibited by engines weighing 10 or 20 lb per horsepower and having low thermal efficiency, so today our vision is clouded by limited rocket-engine performance. Development of efficient propulsion paces the growth of any vehicle system. Superior propulsion, of course, results in smaller vehicles for any given mission, and this in itself is a significant contribution to low-cost space transportation. However, there is a vastly more important point to be made here: Superior engine performance means that the operating characteristics of future vehicles can be greatly simplified. For such missions as a lunar round trip, current engine technology will require several stages; and, since a stage is in itself an individual vehicle, it is necessary to design, develop, and operate several vehicles simultaneously to achieve the flight goal. Use of complex staged vehicles is a crutch imposed by inefficient propulsion.

Re-usable Vehicles Needed

A vast reduction in operating costs of boosters requires development of a re-usable vehicle. It is obvious that this objective is enormously difficult when the various stages are scattered all over the solar system. In fact, only a small economic advantage now appears to exist in the complete recovery and re-use of conventional multistage rocket vehicles, because the recovery techniques which may be utilized with available propulsion are limited.

The current space-plane concept, which might be classed as an evolution of conventional aircraft, attempts to circumvent this basic multistage problem with chemical propulsion.

I believe, however, that the nuclear rocket engine offers an even more promising solution, because it would permit single-stage propulsion on even high-energy missions, such as a planetary round trip, and would allow practical recovery techniques.

In attempting to predict the future, we have a gross advantage over our turn-of-the-century aircraft counterparts. It was certainly most difficult

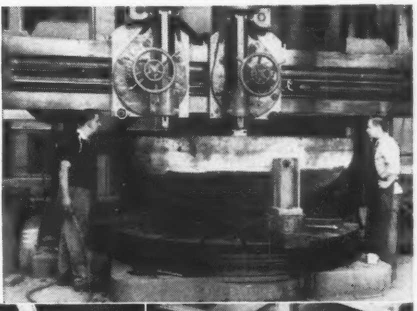
BIGGER THINGS are being done at EXCELCO

• • • like these huge solid rocket motor components for

GRAND CENTRAL ROCKET CO.

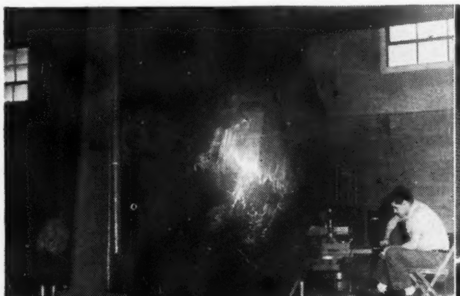
. . . under sponsorship of the Air Force Flight Test Center, Edwards AFB, California.

Machining 120" Big Booster Heads



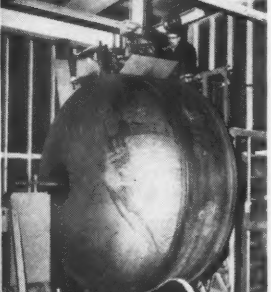
RV-A-10 • Sergeant • Air Force — Re-Entry X-17 • Polaris — Re-Entry X-36 • Jupiter Jr. • Jupiter Sr. • Polaris O • Polaris A • Polaris AIX • Polaris A2-MOD 1-2-3 • Nike Hercules • Nike Zeus • Minuteman • Pershing • N.A.S.A. Programs • Scout • Little Joe and now — **Big Solid Boosters.**

EXCELCO is a small but skilled organization, equipped to handle development and prototype requirements... large or small... for static and flight tests — in the shortest possible time.



Machining 120" Big Booster Heads

Special Automatic Welding of Big Booster Head Assemblies



Big Booster Automatic Welding

Call or write

EXCELCO DEVELOPMENTS

MILL STREET • SILVER CREEK, NEW YORK

Key number 49

for 19th century engineers to forecast with confidence the development of reciprocating engines producing thousands of horsepower at less than one pound per horsepower with excellent thermal efficiency—and even more difficult to anticipate the modern turbojet.

Today, quite clearly, the solid-core nuclear rocket, offering equally significant advances in propulsion efficiency, is possible. Certainly the gaseous-core reactor, with even greater efficiency, is more than the figment of scientific imagination, and may be analogous in importance to the aircraft turbojet.

One-Step Rockets a Key

I have implied that the operating characteristics of rocket vehicles utilizing more efficient propulsion would differ considerably from what we are used to today. Specifically, I refer to a single-stage device which, for example, might be launched and landed vertically under power, in a manner familiar to all readers of science fiction. Such a technique is basically simple and clearly is just as applicable in point-to-point travel on earth as it is to orbital or super-orbital traffic.

Again, the skeptic points out that radiation hazards associated with nuclear reactors may prohibit such an operation. This charge of hazard has been directed at every mode of transportation. It was said of Fulton's steamboat, of the first railroad locomotives, and of automobiles, as well as aircraft. It has always dissipated in the light of rational analysis and experience. Our studies indicate, as a matter of fact, that sound and pressure levels created by a nuclear rocket may be more of an operating problem than radiation. During landing or takeoff of a 1.5-million-lb-thrust nuclear rocket, an observer at a distance of slightly more than 4000 ft from the vehicle would receive a radiation dosage less than the AEC's allowable weekly maximum. In fact, it is not obvious that a nuclear-rocket operating base need be much larger than a commercial airport.

But, the skeptic says, this is normal operation; what of a catastrophic accident? Surely if railroad steam locomotives were prone to frequent catastrophic accidents, rail transportation would never have been developed, and the same may be said for the auto or aircraft. The hazards associated with catastrophic accidents of nuclear engines will be defeated in precisely the same manner as were those of the locomotive and aircraft—by design of reliable hardware and application of appropriate safety procedures.

What about costs? The operating costs of the nuclear rocket engine are not prohibitive. Admittedly, the individual engine cost is high, because the quantity of fissionable material needed to assemble a critical mass is large. But the amount actually lost during operation is small. Hence, if the engine is re-usable, total fuel costs are little more than the basic cost of the propellant.

We have made extensive studies of space-transportation costs, comparing various types of rockets, including the hydrogen-oxygen chemical system. In every case, our estimates have convinced us that the introduction of nuclear rockets—even at performance levels certain today—can significantly reduce operating costs of space travel. No known recovery technique for a chemical rocket would grossly change this conclusion.

And we conclude that with the development of the nuclear rocket will begin the real exploitation of our current space-flight experiments.

In reviewing the entire history of flight, two revolutionary propulsion developments stand out — the reciprocating internal-combustion engine, which gave us the first powered flight, and the rocket, which has opened up a completely new field. It literally gives us the solar system and perhaps, with fusion power, the near stars. ♦♦

Educational Programs

(CONTINUED FROM PAGE 89)

During the graduate years, in addition to seeking outstanding instruction the budding scientist should seek to be associated with a "great teacher," to whom the graduate student would apprentice himself in order to soak in knowledge and wisdom by means of intellectual osmosis. The student thus nourished will upon graduation embark on his own, to make his own mark and score his own accomplishments.

In such a teacher-student relationship, the role of the elder man is, to paraphrase Rabindranath Tagore's philosophy: "Let my guidance like sunlight surround you, yet give you illumined freedom." And the only responsibility which the younger man has is to follow the philosophy of Theodore von Kármán, the dean of the space age, namely to acquire "know-how with think-how."

Sources

U.S. Office on Education, National Research Council, Fund for Advancement of Education, and the National Science Foundation.

Acknowledgement

The authors wish to extend their gratitude to the members of the ARS Education Committee for their many helpful suggestions, and to Mrs. Joy Crane Thornton for her diligent work in compiling the results of the survey. ♦♦

Meet the Growing SOUTHWEST Family of

SPECIAL PRODUCTS for SPECIAL NEEDS

SOUTHWEST'S newly expanded Research and Development Facility developed the specialized products pictured. It is staffed and equipped to render immediate consultation to you for special applications of Southwest products, and for design and development service on new products to serve related problems. Your inquiry is invited.

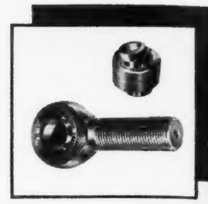
GROWTH through specialization and superiority! From the original MONOBALL® bearing to a family of products so high in performance that thousands are now in use in the nation's leading aircraft and missiles! That's the story of SOUTHWEST'S 16-year growth . . . and it's just a hint of the greater growth expected in the years ahead!

SOUTHWEST PRODUCTS CO.

1705 S. Mountain Ave., MONROVIA, CALIFORNIA, Phone: MUrray 1-9616

MONOBALL®

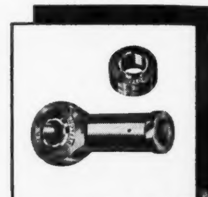
Self-aligning Spherical Bearings . . . plain and rod end types. Stainless steel, chrome and other metals. For severe conditions of high temperatures, vibration and high radial loads up to 893,000 lbs. U. S. Pat. No. 2,626,481.



DYFLON® (Pats. Appl. for)

Self-aligning and self-lubricating Spherical Bearings. Combine MONOBALL® engineering advantages with DYFLON® plastic alloy insert for life-time lubrication. No cold-flow. Impervious to known chemical solvents.

Write for 60-page Engineering Manual No. 551 covering both of above items.



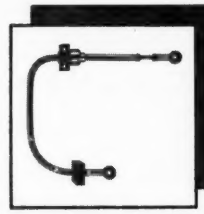
® "Monoball," "Dyflon" and "Flexhot" are registered trade names and are patented and pat. applied for with all world rights reserved.

FLEXHOT® AIR DUCT JOINTS

Utilize MONOBALL® proven two-piece design. Years of flight testing, USAF accepted. Hundreds now in use. Assures years trouble-free service. Flexibility, temperature, pressure, weight and materials to your requirements. U. S. Pat. No. 2,921,803. Ask for Bulletin ADJ-955.

PUSH-PULL CONTROLS

Mechanical. Compression and tension type. Positive remote controls for actuating mechanical, hydraulic, other devices. Three sizes with Ult. Load 3050 lbs.; Ult. tension to 3900 lbs. U. S. Pat. No. 2,441,719. Write for Bulletin No. 1551.



DYFLON® BUSHINGS

Self-lubricating, plain journal bushings. Stainless steel with DYFLON® plastic alloy insert. Capable of dynamic loads to 25,000 psi and static yield loads to 50,000 psi at low rotational speed without damage. Ask for Bulletin No. 1060.

MINIATURES

Ultra-precision, miniature self-aligning MONOBALL® spherical plain bearings and rod ends in corrosion resistant steels. Bore sizes from .046" to .156" with ultimate static load ratings from 225 lbs. to 2550 lbs. For maximum performance in compact, light weight assemblies. Ask for Bulletin No. 461.

Key number 52

A cross-section of the 40 subsystems incorporating 3500 electronic parts which go into TIROS III are framed by two satellites. All components must be thoroughly tested, precisely integrated and must function perfectly if the satellite is to perform successfully.

NASA's Hurricane spotting TIROS III maintains projects' fine performance record

With the successful launching of TIROS III, meteorologists for the first time will see the total cloud formations and measure the radiative energy balance of hurricanes which plague the eastern coast of North and Central America each year. For TIROS III was launched at this time for precisely this purpose. From information gained from TIROS III, meteorologists may learn much more about the birth and life cycle of tropical storms.

TIROS III DESIGN

Although the spacecraft configuration is essentially the same as the previous two highly reliable TIROS satellites, TIROS III has two wide-angle cameras and the National Aeronautics and Space Administration has placed new omnidirectional IR sensors aboard to measure thermal radiation from the earth and sun.

THIRD OF A FAMOUS FAMILY

TIROS III is the third of a highly successful series of experimental weather satellites which were developed, along with the associated ground equipment, for the NASA, under contract with the Goddard Space Flight Center, by RCA's Space Center. All of them have established "firsts" in the United States' space program.

TIROS II established a longevity record for a complex satellite. Still operating after nearly eight months and over 3300 orbits, TIROS II has transmitted over 34,000 photographs to the ground. Aside from its impressive meteorological achievement, historians may well point to this long-term performance as the first to prove that a satellite system could operate reliably for so many months in a space environment thus proving the feasibility of operational satellites.

TIROS I was the first satellite, carrying advanced television equipment, which sent photographs of the earth's cloud cover to meteorologists. From TIROS I's 23,000 photographs, meteorologists found that satellites could be used for weather observation and analysis. The pictorial information is particularly useful in the two-thirds of the world from which few or no weather observations are now available.

CONNOTATIONS FOR THE FUTURE

The TIROS series has proved beyond a doubt that the peaceful uses of space will benefit all mankind. Six nations participated in the utilization of information from TIROS II and more will take advantage of TIROS III. RCA is also already at work on the camera systems and space power supply for NIMBUS, the next generation of meteorological satellites.

If you are a professional physicist, engineer, or mathematician and interested in participating in such challenging projects and stimulating team efforts, contact the Employment Manager, RCA Astro-Electronics Division, Defense Electronic Products, Princeton, N. J. All qualified applicants are considered regardless of race, creed, color or national origin.

Check RCA Booth 375 at ARS Space Flight Report to the Nation, N. Y. Coliseum, October 9-15, 1961.

RCA

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

Key number 53

Space Flight and Science

(CONTINUED FROM PAGE 47)

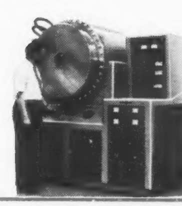
imously in stating that:

> "From a scientific standpoint there seems little room for dissent that man's participation in the exploration of the moon and the planets will be essential if and when it becomes technologically feasible to include him. Man can contribute critical elements of scientific judgment and discrimination in conducting the scientific exploration of these bodies which can never be fully supplied by his instruments, however complex and sophisticated these instruments become. Thus, the carefully planned and executed manned scientific expeditions will inevitably be the more fruitful.
>
> "Moreover, the very technical problems of control at very great distances involving substantial time-delays in command signal-reception may make perfection of planetary experiments impossible without manned controls on the vehicles.
>
> "There is also another aspect of planning this country's program for scientific exploration of the moon and planets which is not widely appreciated. In the Board's view, the scale of efforts and the spacecraft size and complexity required for manned scientific exploration of these celestial bodies is unlikely to be greatly different from that required to carry out the program by instruments alone.
>
> "In broad terms, the primary scientific goal of this program is immense—a better understanding of the origins of the solar system and the universe, the investigation of the existence of life on other planets, and potentially the understanding of the origin of life itself. In terms of conducting this program, a great variety of very intricate instruments (including large amounts of auxiliary equipment . . .) will be required. It seems obvious that the ultimate investigations will involve spacecraft, whether manned or unmanned, ranging of the order of hundreds of tons so that the scale of the vehicle program in either case will differ little in its magnitude. . . .
>
> "The Board strongly urges the official adoption and public announcement of the foregoing policy and concepts by the U.S. Government. . . .
>
> "While the Board here has stressed the importance of this policy as a *scientific* goal, it is not unaware of the great importance of other factors associated with the United States' man-in-space program. One of these factors is, of course, the sense of national leadership emerging from a bold and imaginative U.S. space activity. Second, the members of the Board as individuals regard man's exploration of the moon and planets as potentially the greatest inspirational venture of this century and one in which the entire world can share; inherent here are great and fundamental philosophical and spiritual values which respond to man's questing spirit and his self-realization as a sentient being. Elaboration of these factors is not the purpose of this document. Nevertheless, the members of this Board fully recognize their parallel importance with the scientific goals and believe that they should not be neglected in seeking public appreciation and acceptance of the program."

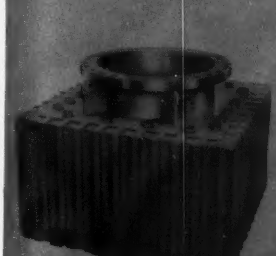
This recommendation comes from a large group of very diligent scientists after two years of detailed study and debate within the Board on the intricate problems and opportunities in space exploration. At this point, we might recall that in the 1954-55 era there was a certain amount of opposition to the proposed IGY satellite program. Now opposition to satellite programs has entirely disappeared. Very large payoffs, in both science and applied fields, can now be perceived clearly from satellite research so that apology is no longer necessary. In science, satellite experimentation has provided the cement that has joined centuries of unconnected geophysical observations into a now solid block of scientific comprehension and generalization. The cost of the IGY satellite program was scarcely more in effort than the precedent earthbound research on solar and terrestrial relations over the preceding century. The cost was paid in a shorter time, and our comprehension improved at a correspondingly more rapid rate. Powerful satellite tools could do quickly what weak tools could not accomplish at all.

But for the past three years of research with rockets and satellites, we would still be spending large amounts of money and effort on solar and terrestrial relations. We would be still employing only the earlier methods, inadequate by themselves, without getting much closer to the basic scientific truths involved. In those three short years we have seen the sun in the full ultraviolet and X-radiation spectrum, found great unsuspected variations over its surface, and examined the whole range of eruptive phenomena in detail. The relationship of these eruptive effects to geomagnetic auroral phenomena is far better understood. The Van Allen Radiation Belts have been discovered, and the earlier Stormer calculations of electron reflection in the geomagnetic field have been rationalized as a consequence. Out of a whole series of satellite discoveries, the general subject area of solar and terrestrial relations, outer atmospheric physics, geomagnetism, auroral physics, and space fields and fluxes of particles and radiations is becoming a coherent science. This science of the earth's environment is but one of the many examples of the outstanding success of satellite physics.

In looking back over three years of



IT'LL NEVER GET OFF THE GROUND



5,000-litre/second VacIon pump

Fortunately, Varian's VacIon® pump systems don't *have* to get off the ground to simulate hyper-altitude conditions. This makes life a good deal easier for scientists who choose to study outer space without becoming a part of it.

"Packaged" vacuums can be provided for suitcase-size chambers or giant rooms containing complete missiles. Republic Aircraft's new space chamber will use a 5,000-litre/second VacIon pump system. Convair and NASA are already operating VacIon pumps in hyper-altitude experiments.

Any scientist with his feet on the ground can get 150 miles of altitude from a Varian electronic pump system. Write *Vacuum Division.*

VARIAN associates

PALO ALTO 56, CALIFORNIA

Subsidiaries:

BOMAC LABORATORIES, INC.
VARIAN ASSOCIATES OF CANADA, LTD.
S-F-D LABORATORIES, INC.
SEMICON ASSOCIATES, INC.
SEMICON OF CALIFORNIA, INC.
VARIAN A.G. (SWITZERLAND)

Key number 55

satellite physics, one can show step-by-step the unforeseen, but powerful influence that its observations have exercised on the comprehension of our terrestrial environment. Nor is our scientific knowledge of the space surrounding the earth as yet by any means complete. We have immense explorations ahead to determine the strength and orientation of the interplanetary field. The character of the solar winds, the time fluctuation of the radiations from the sun that we are just now defining, and a hundred other questions can be projected. These now are within the range of our scientific capabilities using satellites and simple space probes.

But pure science has not been the only payoff from our satellite program. Turn for a moment to the emergent technology. One can predict without hesitation, without danger of being contradicted, that by the end of this century, and perhaps even by the end of this decade, space communications based on satellites will alone, through the annual taxes collected on new industry, repay all of our non-military space costs prior to 1961. Thereafter, the advantage of our treasury will be enormous. The wonderful promise of meteorological satellites and their certain contribution to our meteorological knowledge will be realized beginning with the Nimbus next year. Already we have seen demonstrated the effectiveness of navigational satellites. Perhaps such satellites will provide the most effective and efficient form of navigation for our fast, and even not so fast, transportation. And, finally, in these days of tension we cannot ignore the importance of military satellites in the fields of surveillance, intelligence and early warning. These may be the means of calming the nerves of a very troubled and very jumpy world. And so, from our vantage point of 1961, what seemed to be a very expensive satellite program in 1954 and 1955 is providing us an immense payoff; indeed it is only a rather small investment compared to the enormous resulting opportunuities for benefitting mankind and expanding our fiscal resources.

All of this is past history, and it is useful primarily in noting that authority can sometimes be very fallible in asserting that scientific and technological promise should not be followed vigorously. In light of this unreliability of authority, I shall endeavor to give what may be an equally unreliable assessment of the value to mankind of the next step; that is, manned exploration of the moon and the planets at a cost of \$20–40 billion.

Since our expenditures for science and technology over this coming decade in any case will average some \$15–\$16 billion, or about $2^1/_2\%$ of our gross national product, the question is: Can we afford to expend, let us say, \$3 or $\$3^1/_2$ billion a year extra for the next 10 years to accomplish this objective? This is about 30% more than we spent in 1960 for our research and development bill. Accordingly, I must try to estimate what the scientific payoffs will be and what will be their value.

Turning first to scientific exploration of space, we face a number of major problems on which considerable effort must be expended. The first is the conduct of experiments in an external environment very different from that on the earth. The second is the design of experiments to produce critical and analytical answers under conditions in which the experimenter is more or less insulated from manipulation of the experiment. A third involves the rather considerable void of knowledge concerning the capability of the experimenter or explorer in a radically different ecology and the problem of his adaptation to that ecology. To satisfy these questions a broad range of precedent research must be done. For example, one just cannot walk around the moon with a geologist's hammer to do geology (or "lunology") as we do it on earth. Instead, rather sophisticated new methods will be required which are matched to the capabilities of the explorer in his new environment.

In the field of biology, you are simply not going to sit on a planet with a test tube in your hand for two years waiting for a culture to grow. We must develop very excellent quantitative electronic methods of measurement in the field of biology which generally do not now exist. When developed, this apparatus, to do the job on the moon and planets, will have very wide applicability on the earth and will advance sciences in the terrestrial laboratory in very significant and important ways.

Science on the moon and the planets is a discipline which forces us to deal with all scientific experiment in the same way the nuclear physicist must deal with atoms—without being in direct sensory contract with those atoms. The nuclear physicist long ago found that the materials with which he must deal—the atoms, the nuclei, the mesons, the nuclear products, the nucleons—were by nature outside the capabilities of his senses to detect. Consequently, he was forced to develop rather elaborate apparatus which made quantitative measurements far removed from his direct senses a procedure that has advanced nuclear physics very rapidly indeed. Because of the discipline which space science will force on science generally by creating a whole new body of experimental and quantitative techniques, those great fields to which the modern quantitative measurements have not yet extended will be affected mightily.

Turning to scientific problems on the moon and the planets *in situ*, one thinks first of all of their atmospheres. Of course, the moon has a very nebulous atmosphere, but this is not the case on the planets. We are interested in the composition of these atmospheres, their circulation and their thermodynamics under the particular situations in which the gravitational fields and the Coriolis forces are much different than on the surface of the earth, and where the heat balance will differ radically. We are interested in the electrification of these atmospheres under radically different conditions that under no circumstances can be reproduced for test on the earth. We are interested in the surfaces of the planets, the geology, petrography, geomorphology, and the historical geology, especially as indicators to cosmography and cosmogony. On the surface of the moon, one suspects that there has never been an atmosphere and therefore the primordial surface may be very accessible, a condition beyond man's reach here on earth. In geophysics one wants to look at the magnetic field of the planets, whether the other planets have seismology, what is the nature of their tectonophysics and their geochemical history. Quite clearly, erosion patterns will be very different on planets having differing atmospheres and differing amounts of water or other solvent.

I would venture to predict that the discoveries to be made in lunar and planetary exploration will give us an entirely new scientific view of our own earth by supplying independent frames of reference in which to interpret terrestrial data.

Turning to biology, there is more than a suspicion that at least the planet Mars may have a form of biology with a carbon-oxygen base. This is perhaps the most exciting prospect of all in our future space projects, of which the step to the moon is simply the first. Here is the opportunity to examine the generation and the evolution of life under completely different ecological conditions—different atmospheres, perhaps different forms of solvents, and in fact all the differences that can occur on another planet.

Although extremely doubtful, it is not absolutely inconceivable that some form of life such as very primitive micro-organisms might be found on

(CONTINUED ON PAGE 145)

ce
ly
x-
h-
he
ts
ed

he
he
es.
u-
he
r-
se
eir
ar
al
ch
he
ill
in
es
ns
e-
Ve
he
o-
ol-
s-
he
at
re
ce
on
in
he
er
y,
o-
y.
be
f-
ng

he
d
n
ur
nt
r-

re
et
h
r-
ll
h
t.
he
fe
al
r-
d
n

is
he
ve
on
)

An important message for Scientists and Engineers

SC

Fo

SCIENTISTS AND ENGINEERS:

Follow-On Atlas Programs Mean New, Long-Range Opportunities.

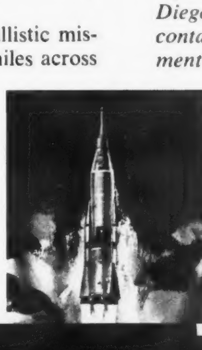
Now operational, the Atlas weapon system stands as a unique symbol of scientific, engineering and military achievement. The design, development and testing of this reliable missile was an undertaking of immense complexity. Scientists and engineers at General Dynamics | Astronautics worked constantly at the most advanced state of the various arts involved. Boldly, they introduced and proved entirely new concepts of rocketry, and in record time they developed the Atlas.

The same depth of imagination and technical daring is now at work modifying and adapting this sophisticated machine for a variety of civilian and military space missions. Dozens of specialized orbiting and inter-planetary vehicles will depend upon the power of Atlas to thrust them into space. These programs reach far into the future and require the skills of highly resourceful engineers and scientists in many technical disciplines.

Atlas is the free world's first intercontinental ballistic missile; the first missile to travel more than 9,000 miles across the earth's surface; the only one to lift itself into orbit. Atlas marked the first use of swivel engines for directional control and it was the first to use airframe skin as fuel cells.

Many more "firsts" lie ahead for this reliable rocket. If you are the sort of inventive engineer or scientist who can contribute ideas and solutions to the problems surrounding the mastery of space, you and General Dynamics | Astronautics have a common interest.

You'll find most of the details on this and the following page, plus a convenient inquiry card. If the card has been removed, or if you wish to furnish or request more detailed information, write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Dept. 130-90, General Dynamics | Astronautics, 5698 Kearny Villa Road, San Diego 12, Calif. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York Placement Office, 1 Rockefeller Plaza, CIrcle 5-5034.)

GENERAL DYNAMICS  ASTRONAUTICS GD

(Formerly CONVAIR | ASTRONAUTICS)

PROFESSIONAL PLACEMENT INQUIRY

This card may be folded and sealed or stapled and mailed in complete confidence. It will enable the professional staff at General Dynamics | Astronautics to make a preliminary evaluation of your background. A personal interview can be arranged in your city by appointment. Every completed inquiry will be acknowledged.

NAME ____________________

STREET ADDRESS ____________________

CITY & STATE ____________________ TELEPHONE ____________________

NEAREST MAJOR CITY (IF APPLICABLE) ____________________

COLLEGE GRADUATE: YES ☐ NO ☐ DEGREE: BS ☐ YR____ MS ☐ YR____ PHD ☐ YR____

MAJOR SUBJECT:

AERONAUTICAL ENGINEERING	☐	MECHANICAL ENGINEERING	☐
ELECTRICAL ENGINEERING	☐	MATHEMATICS	☐
ELECTRONIC ENGINEERING	☐		
CIVIL ENGINEERING	☐	PHYSICS	☐

OTHER ____________________

FOLD

EXPERIENCE:

PRIMARY SPECIALTY ____________________ YRS. ________

SECONDARY SPECIALTY ____________________ YRS. ________

ADDITIONAL COMMENTS, IF ANY, CONCERNING YOUR JOB INTERESTS:

____

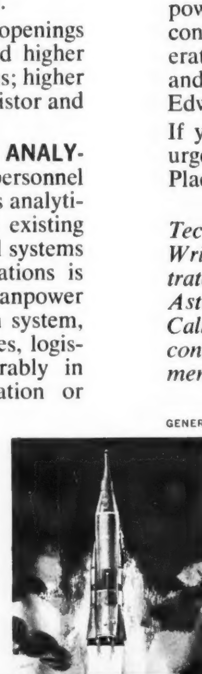
____

____

____

____

PLEASE SEND GENERAL DYNAMICS | ASTRONAUTICS RECRUITMENT BROCHURE: A-10 ☐



the moon. Conditions on the moon are very extreme in terms of high and low temperatures, the lack of atmosphere, and the direct accessibility of lethal radiations to the surface. Nevertheless, there have been some suggestions that for any one of a variety of alleviating reasons, some forms of life might have been produced and might have survived and evolved on the moon's surface. For example, there are small areas near the lunar poles always in a more equable twilight, water of crystallization may be available in caves, etc.

Absolute assertions are not prudent without more knowledge of the origin and processes of limiting forms of biology. But the more exciting prospect comes out of the proposals to explore the planets for the primitive life that may have generated and evolved on their surfaces under ecological conditions radically different from those of earth.

When we speak of life on the planets, we almost implicitly refer to life in the form of micro-organisms or very primitive organisms, though Keffer Hartline once jokingly remarked, "While you're looking through your microscope for these micro-organisms, you may be stepped on by an elephant." As to the character of such organisms one suspects that the accidents involved in the evolutionary process may lead to organisms that have certain similarities to our own and certain radical differences. The similarities would arise out of the fixed shapes and binding forces of the component molecules and their atoms from which these organisms were assembled. On the other hand, gross differences would arise from the radical differences anticipated in the evolutionary process as it goes on in a different environment.

My biological friends point out that, in the course of evolution on the earth, some forms of organisms that preyed on others have led to the particular evolutionary chains which we observe on the earth. This is the well-known ecological influence on evolution. Thus, the evolutionary processes on another planet might be radically altered not only by the environment, but also be the course of ecologic history.

Of course, any speculation on the potentiality and form of life on another planet either now or at some distant age is necessarily pretty wild and unscientific—it is only permissible on very tenuous evidence and because the opportunity for planetary exploration is in sight. Reasoning from some important evidence, scientists like Abelson have raised some doubts that life on other planets will be found at all.

Even confirmation of this would be important.

Nevertheless, we know almost nothing about the circumstances—the range of ecology under which life can occur—and planetary exploration will vastly advance this knowledge. Thus one estimates, along with many biologists who have studied the problem, that space exploration may very well yield a far more significant leap in biology than would the regurgitation of the same old terrestrial experiments with slight variations.

Then one comes to the question of the influence of different planetary environments on life—human and other—that has evolved on earth. This involves the influences of different gravitational fields, of different rhythmic patterns, as well as other environmental factors. Some of this research can be done in satellites; but for extended experiments, the planetary environment will eventually prove much more effective. These questions have particular pertinence to explorers who will spend some time on the planets where problems of aging and replacement of living tissues and food supply will become important. But this work also has great relevance to understanding terrestrial biological and evolutionary processes through new frames of reference.

While it is quite impossible to predict specific gains beyond those acquired from the technological dexterity we shall acquire, one knows from past experience that new vistas will open that are at least as promising as those realized from satellite technology. Yet, only 10 years ago, even these were obscure and unrecognizable.

Before concluding, we cannot avoid some words of caution. These danger flags must not be ignored and their hazards maturely recognized in planning space exploration. First is the problem of contamination. When we succeed in landing on the planets to examine the life there, we will have succeeded in achieving perhaps the most treasured scientific opportunity in all time. And yet there is danger of destroying that very opportunity in going about the job carelessly. The danger could arise either because the U.S. proceeded carelessly or because the USSR proceeded carelessly. For the micro-organisms that we could introduce onto the planet might easily spread over the planet to destroy or mask the very evidence for which we are looking. Therefore, extreme caution must be exercised to avoid contamination or destruction of the sensitive evidence of life by introducing alien terrestrial micro-organisms. This destructive process would be simply irreversible; this kind of repressed evi-

dence cannot be recreated. At best there are only two planets, more probably only one, which have developed the kind of evidence that we want. So each step in planetary exploration must be planned meticulously to insure preservation of the most important scientific evidence.

Then, too, we must worry about back-contamination. We tend to think of this as fairly unlikely, but biologists admit that back-contamination is a definite possibility. What form back-contamination might take, no one can predict without research on the planet itself. We might observe that Mars has no oxygen at present, yet its evolution seems to have been very similar to that of the earth—so why does it not have oxygen? Someone might postulate that a micro-organism capable of fixing the oxygen into the surface materials had at some age appeared and succeeded in removing the oxygen from Martian atmosphere; more likely it is because Mars has little free water at the present time so that it cannot support the biology in sufficient abundance to release oxygen to its atmosphere. Nevertheless, there are a variety of possible micro-organisms conceivable which we might not want to introduce back onto the earth. Such organisms might be very vicious from the terrestrial viewpoint because our own organisms had evolved no resistance against them. So when we go into planetary exploration, we must proceed with our eyes open to be sure that the problems of back-contamination are very carefully studied *in situ* and do not offer any serious danger to the earth.

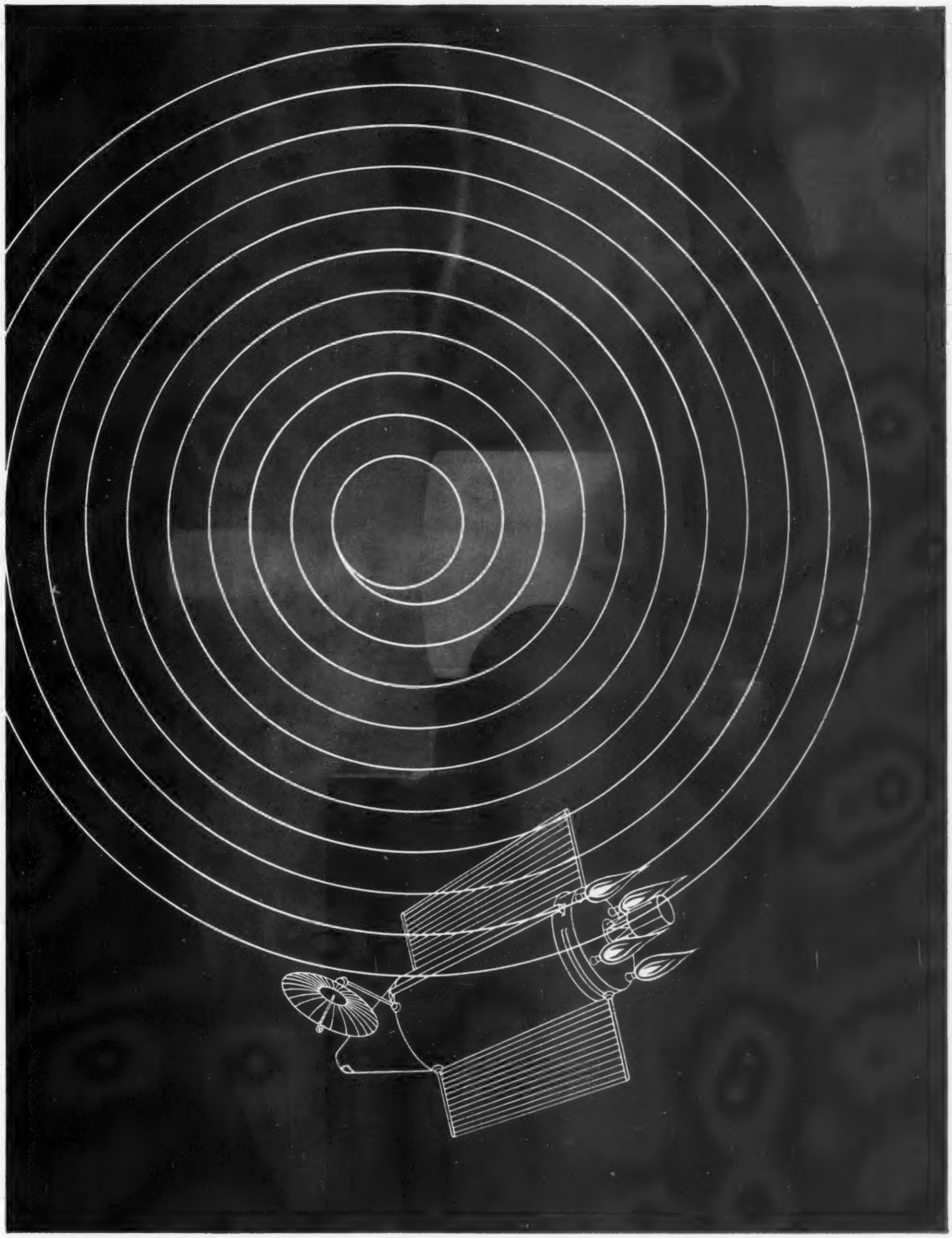
Another caution relates to the time and basic research required to devise and design those very experiments that are essential to good science on the planets so that they are ready to fly when our spacecraft are available. The great success of the present U.S. program of satellite physics has been realized because a few scientists were able to foresee and to prepare for the potentialities of satellite research years in advance. Consequently, we were prepared to put significant experiments on satellites as soon as they were available. But will the much more sophisticated experiments for lunar and planetary science be ready by the time we are ready to fly the 10-, 20-, 50-, and perhaps 200-ton spacecraft in the future?

I doubt it, unless we put much greater emphasis on the basic experimental science to be done on the moon and the planets. We have to be very careful that expensive space voyages do not involve superficial science. We have to be very careful that we do things in the right order. We cannot permit the rush toward some silly "first," which may be very transient, to destroy the immense power and the mighty advances which space science really offers. So to avoid delay, the development of experimental techniques and the plan for proper and critical experiments must proceed rapidly and with care.

When one reviews these cautions, the need for international cooperation seems imperative. While at the moment unrestrained competition does no harm, and even lunar flights pose no serious problem, the problems of competition become uncontrollable when planetary exploration is involved. With the planets, each step must be taken only after the most careful premeditation and international consultation if vital evidence is to be preserved and the dangers of back-contamination avoided. One hopes that the Committee on Space Research (COSPAR) is able to subordinate national rivalries to the solid scientific objectives ahead. The ultimate expectation of retaining a strong voice in international control of procedures in planetary exploration and the prevention of a single national monopoly of space exploration may be among the most compelling reasons for our heavy investment in space exploration at this time.

Finally, I would say a word about man in space. Is it possible to do with instruments everything that could be done with man? After all, when you send some man up there it is going to cost a couple of hundred tons (perhaps not quite that much to the moon but certainly that much or more to the planets). Just think, some say, what you could do with all those instruments. This is enough to make any electronicist's mouth water. But, of course, the problems in instrumentation are very severe too. You have to balance a variety of factors. How do you do the experiment? What information do you want the experiment to give you which will be critical with respect to the observation? How can this information be reduced to avoid redundancy? How can it be transmitted over a couple of hundred million miles? This means very great power and narrow bandwidths, for you don't want to spend hundreds of years transmitting the essential information. You would like to be able to reduce your data automatically so that the instruments could write the scientific paper on the planet without redundancy, but this is a little too much to expect of machines or instruments at the present time.

Because of the broad range of the problems involved, because of man's restricted knowledge of the planets at



the moment and because of the improbability that he can pre-set his instruments to work in just the range of the phenomena that he wants to observe, because we may not even know what is most important to look for, it seems unlikely that instruments can compete with man's brain in dealing with the major problems in the foreseeable future. Man's insight and judgment still win the competition where the most sophisticated problems are concerned. Moreover, since the servo-time between the earth and the planets is unconscionably long (15 min or so), human monitoring and judgment in landing and takeoff seems essential for a long time to come.

And so I would offer the opinion that for many years to come, it will take man on the planets to get the most out of the instrumentation. This is not to say that a great deal cannot be obtained from instrumentation, but man cannot be discounted when the whole job is considered. And this is in spite of the fact that man must be insulated from much of his space environment because of the lethal character of that environment.

In conclusion, I remind you that the character of the decision to explore the moon and planets is not very different from that which had to be made in the 1490's by King John of Portugal and shortly thereafter by King Ferdinand and Queen Isabella of Spain. The problem before us now, as then, is not whether it is scientifically or technologically possible to do this exploration; the question before us is *should* we do it?

King John in Portugal received Columbus, listened to his "wild" proposals, and said, "Look. This is much too expensive; I'm sure that my subjects will need this for health, medicine, food, etc., and therefore, I couldn't think of supporting an expedition to the West." At that time Portugal had a standing comparable to that of the U.S. today. And then Columbus went to Ferdinand and Isabella, and we all know the result of their imaginative support in opening the New World.

The decision of President Kennedy has this same quality. Perhaps, even likely, by the end of this century, man will have been repaid many times over for the \$20-\$30-40 billion which this program will cost him. ♦♦

Microdot Awarded Contract on Midas

LOS ANGELES, CALIF.—Contracts in excess of $225,000 have been awarded to Microdot Inc. by Philco Corporation's Western Development Laboratories for UHF narrow-band data link transmitters and subassemblies to be flown in the Midas missile alarm satellites.

The Midas project, under cognizance of the United States Air Force, is aimed at development of a national early warning capability through multiple satellite coverage of the earth's surface via infrared detectors. Philco, with responsibility for the instrumentation, is an associate contractor to the Air Force. Lockheed Missiles & Space Company, prime system contractor, is responsible for the total vehicle and ground elements of the system, integrating associate and subcontractor efforts.

Microdot model 2406A UHF Telemetry Transmitter, similar to units now in production for the Midas satellite program.

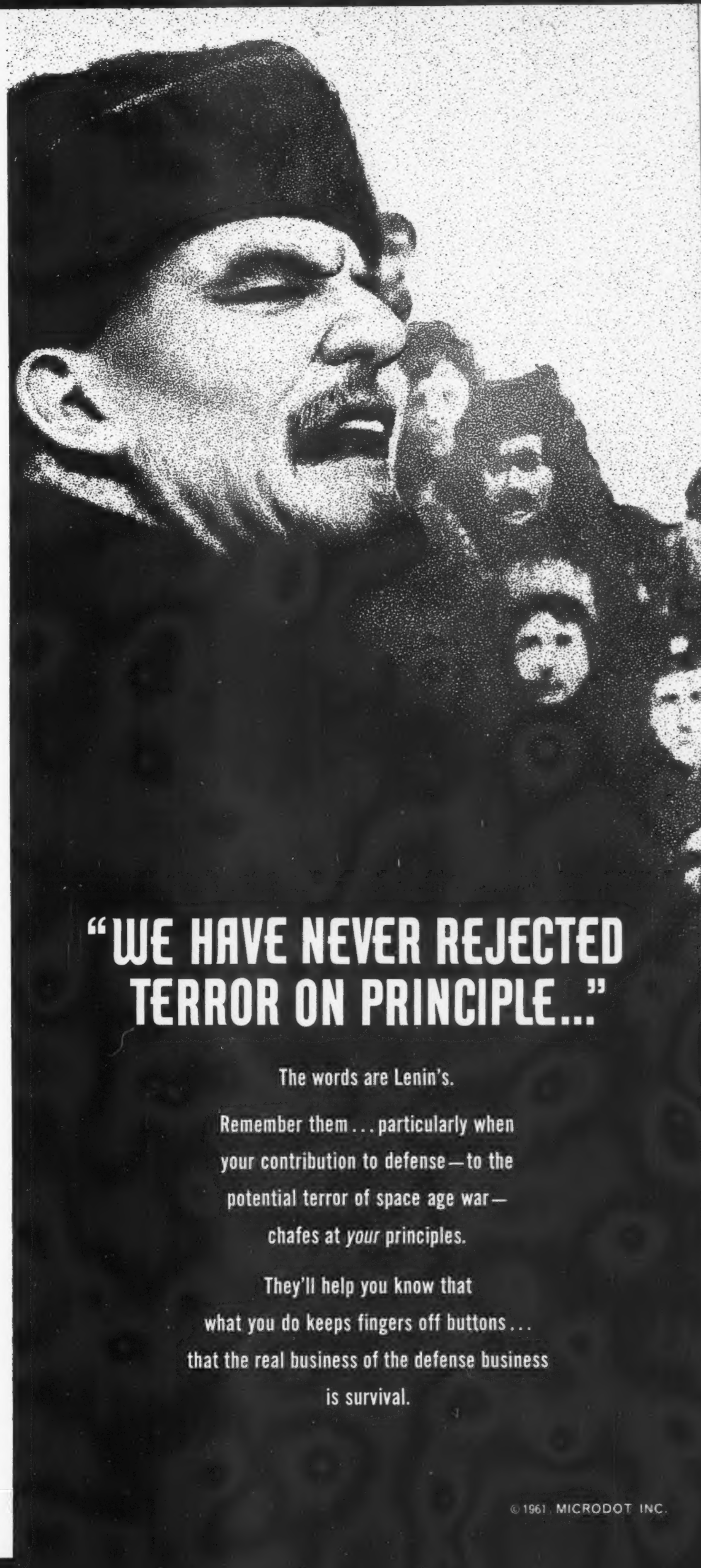
In May, 1960, a Midas satellite was launched into near perfect orbit 300 miles in space. The 5000-pound satellite, over 21 feet high, carried a 3600 pound instrumented package. Then in July of this year, Midas III was placed into an 1850 nautical mile orbit. Again a near perfect circular orbit was achieved. Continuation of test firings are anticipated with the program remaining a high priority national development.

For Midas, Microdot will supply their Model 2406A Telemetry Transmitter modified to include self-monitoring and telemetering of its own operation. The transmitter is miniaturized, pressurized, and includes its own solid state power supply. Reduction in size is gained through use of a unique automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. The transmitter weighs 12 pounds. Similar Microdot telemetry equipment has been a part of such projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone, and Echo I.

MICRODOT INC.

220 Pasadena Avenue
South Pasadena, California

Key number 63



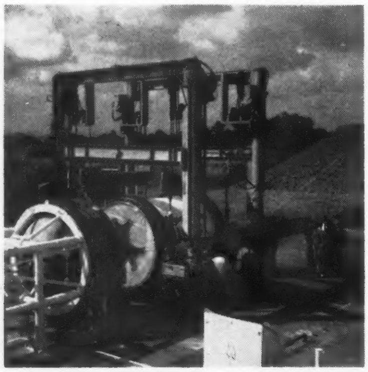
DESIGNS FOR TOMORROW

Plans, Developments, Products, and Processes on Display at SFRN

Companies are listed alphabetically. Additional information on any of the products listed in this section may be obtained by filling in the appropriate key number(s) on the Reader Service card on page 177.

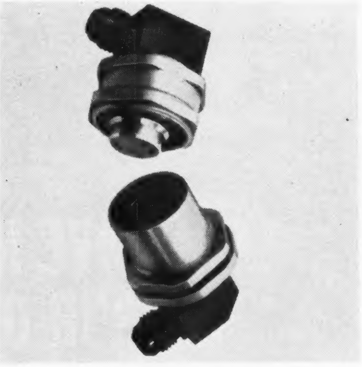
ARS PROGRESS SERIES
Academic Press, Inc., New York, N.Y.
Booth Number 559

Selected papers published on specialized symposia sponsored by the American Rocket Society, together with other papers on the same subject, have been compiled into the volumes listed below in order to fulfill the increasing need for publication media of the many new fields under investigation by the technical committees of the Society. The volumes serve to keep informed those active in research: Aerodynamicists, aeronautical engineers, physical chemists, applied physicists, nuclear engineers, development engineers. The volumes available are: Vol. 1, Summerfield, Martin (ed.), Solid Propellant Rocket Research, 1960, $6.50; Vol. 2, Bollinger, Loren E., Goldsmith, Martin, and Lemmon, Alexis W. Jr. (eds.), Liquid Rockets and Propellants, 1960, $6.50; Vol. 3, Snyder, Nathan W. (ed.), Energy Conversion for Space Power, 1961, $7.25; Vol. 4, Snyder, Nathan W. (ed.), Space Power Systems, 1961, $6.00; Vol. 5, Langmuir, David B., Stuhlinger, Ernst, and Sellen, J. M. Jr. (eds.), Electrostatic Propulsion, 1961, $5.75.
Key number 301



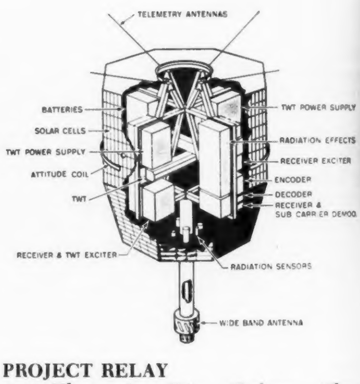
SOLID FUEL ROCKET MOTOR
Aerojet-General Corp., Solid Rocket Plant, Sacramento, Calif.
Booth Number 345

The Air Force Large Solid Rocket Motor Program is demonstrating the feasibility of large high thrust 100-in. diam solid-propulsion systems based on the segmented concept. Thrust records have been established with each of the four successive firings in the program which has not known failure. Largest motor fired was a 55-ton unit which produced a thrust of nearly 500,000 lb for its full duration. Based on the building block concept, this motor was composed of three basic segments; forward, center and aft assemblies mated with Aerojets' lock-strip segmenting joint so simple that field assembly takes less than 5 min. Already being fabricated for early testing are higher thrust, longer duration motors containing several center segments. Although a feasibility program now, these motors in clusters could form booster stages for huge space vehicles.
Key number 302



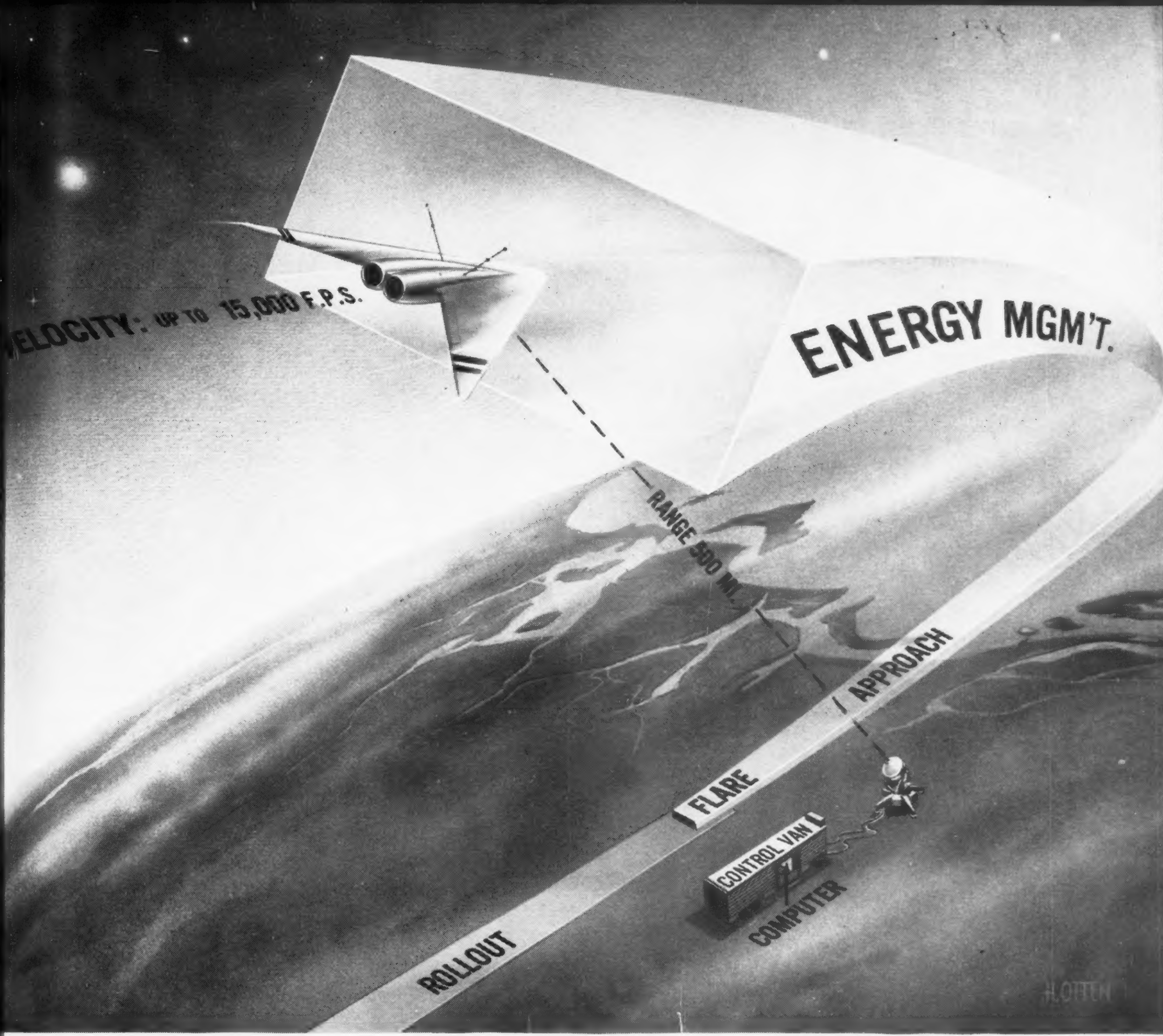
QUICK DISCONNECT COUPLING
Aeroquip Corp., Aircraft Div., 300 South East Ave., Jackson, Mich.
Booth Number 173

This self-sealing coupling is used to connect coolant fluid lines to airborne rack and panel-mounted electronic modules. Coupling connection and disconnection is automatically accomplished by closing or opening the drawer. The coupling is self aligning upon connection, accommodates over-under travel, and includes a capillary pressure relief port. The no air inclusion, no fluid loss valving eliminates spillage of fluid on electronic components. Other features include compatibility with most dielectric fluids and systems with pressures to 500 psi and fluid temperatures of -65 to $+350$ F. All these features are incorporated in a 4 in. long coupling weighing $4^3/_4$ oz. The coupling may be used for any panel-mounted quick-disconnect applications.
Key number 303



PROJECT RELAY
Astro-Electronics Div., Defense Electronic Products, Radio Corporation of America, Princeton, N. J.
Booth Number 375

Project Relay is the first active repeater communications satellite in NASA's research and development program to determine the feasibility and technology of satellite communications systems. The eight-sided Relay satellite, weighing approximately 100 lb, is 26 in. in diam and 29 in. high excluding antennas. Power will be furnished by approximately 6000 solar cells. The satellite will contain two transponders, each capable of receiving and transmitting either television, two-way telephone, or other forms of wide-band data. Other instrumentation includes two command control receivers, decoders, telemetry equipment, beacon transmitter and radiation measurement equipment. In addition to the communications experiments, Relay, which will be in a highly elliptical orbit, will also measure the intensity and distribution of electrons and protons in space and the extent of damage that these particles cause to semiconductors such as diodes and solar cells.
Key number 304



Radio Tracking and Computer Techniques to Return Re-usable Boosters and Space Vehicles

The high kinetic energy of vehicles returning from space and orbital missions creates a problem in energy management. Any system intended to perform such an acquisition and terminal guidance function must have sufficient range and accuracy to pinpoint a vehicle which has re-entered the atmosphere and is still traveling at velocities up to 15,000 f.p.s. This energy must be dissipated, avoiding overheating and overstressing the craft, while the vehicle is safely guided to a normal landing at a designated landing strip.

General Electric Company's Defense Systems Department has an automatic landing system under development which utilizes a precise track radar, a radio-command beacon aboard the vehicle and a digital computer installed in a control van on the ground—all equipment currently in production.

Direct communication with the re-entry vehicle is achieved to maintain a command link for guidance signals and safe energy management. The new landing system is applicable to returning space vehicles and re-usable booster missiles, and is transportable by air or truck. It has been "flight tested" in simulated computer flights and is ready for implementation and application to a specific vehicle. It also will be tailored to the specific vehicle's characteristics.

For further information on how to incorporate radio tracking techniques into your vehicle recovery system write: Defense Systems Department, Dept. DS-100, Syracuse, New York. 170-02

The Defense Systems Department's landing system incorporates the use of: an AN/TP Q-10 Radar, a G-E 225 Digital Computer and Mod IIIG Airborne Transponder and Decoder. Total airborne weight—about 28 lbs.

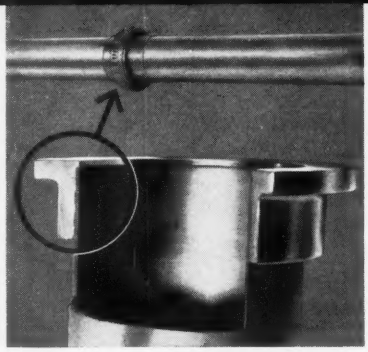
DEFENSE SYSTEMS DEPARTMENT

A Department of the Defense Electronics Division

GENERAL ELECTRIC

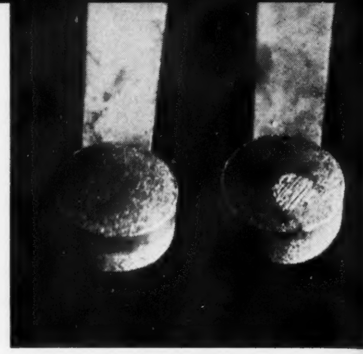
SYRACUSE, NEW YORK

Key number 64



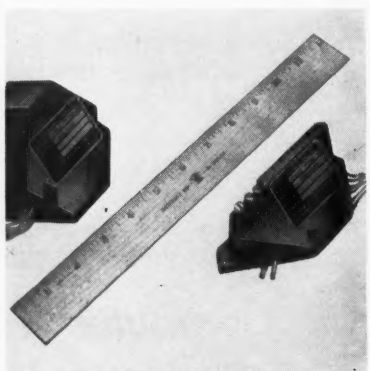
TUBE FERRULES
Avica Corp., Newport, R.I.
Booth Number 156

The mechanical attachment of metal ferrules to metal tubing is an advanced development of swaging by Avica. The method assures dependable joints in piping systems subject to unusually severe operating conditions. Avica tube ferrules eliminate problems of welding or brazing, are suitable for both rigid and flexible metal tube assemblies, and are adaptable to a variety of seals and clamps. Tested for pressures of over 25,000 psi and for vacuum to 10^{-7} mm mercury, joints are not impaired by extremes of vibration, pressure, impulse, and shock. For services from the cryogenic to superalloy temperature range, ferrules are made in many metals in sizes from 0.25 in. ID upwards for heavy and light wall tubes. Now used in piping systems for propellants, fuels, hot gases, etc. the ferrules offer dependable joints at low cost. They can be field or factory installed for similar demanding uses.
Key number 305



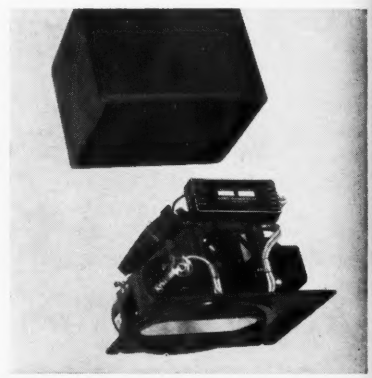
VAC-KOTE
Ball Brothers Research Corp., Boulder, Colo.
Booth Number 232

In a high vacuum, if two metals are in contact with no protecting surface layer, spontaneousmicroscopic welding takes place. Vac-Kote retards welding by reducing the adhesive and cohesive forces. Vac-Kote reduces wear in high-vacuum environments by imparting an artificial two dimensional atmosphere on surfaces such as slip rings, motor brushes, and bearings. Slip rings treated with Vac-Kote have operated under high vacuum conditions (10^{-8} to 10^{-9} mm Hg) as long as 1300 hr and 10^7 revolutions. Motors and bearings will operate even longer. Vac-Kote is being used on NASA's S-16 Orbiting Solar Observatory. Slip rings, servo motors, and bearings have been coated with this material. Vac-Kote can be used effectively where moving surfaces, in contact with each other are required to function in a high vacuum.
Key number 306



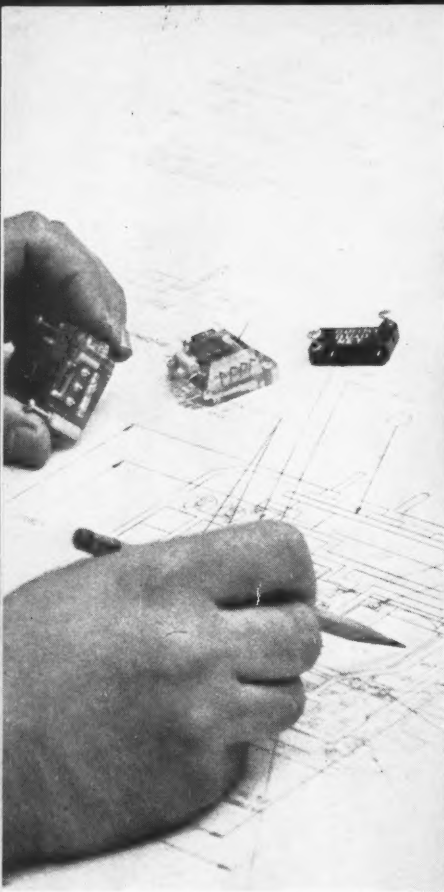
TEMPERATURE CONTROL SYSTEM
Barber-Colman Co., Aircraft and Missile Products Div., Rockford, Ill.
Booth Number 166

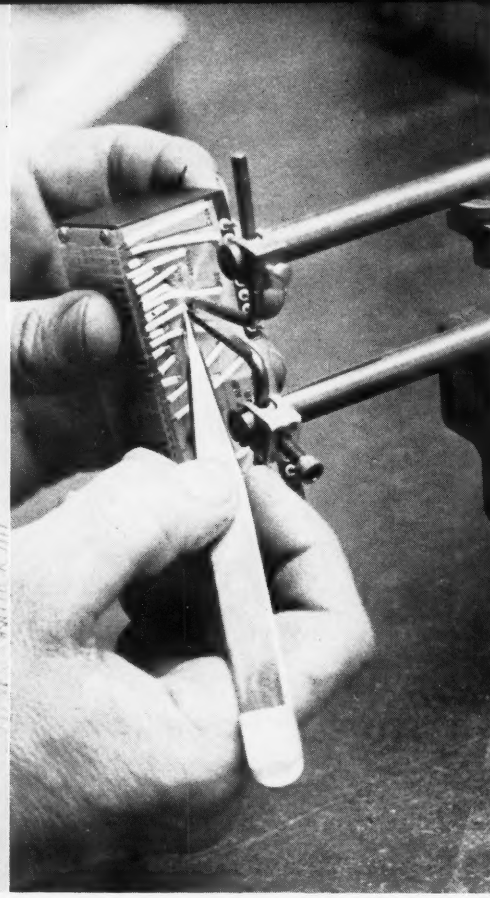
Three uniquely designed control boxes and one element compose the temperature control system for an important section of the guidance system in the Titan missile. The form fitting shape was necessary to fit into the limited space available. This system is so sensitive that it maintains the temperature of a fluid to within a few hundredths of one degree. This system may have advantages of precise control in many other similar critical applications.
Key number 307



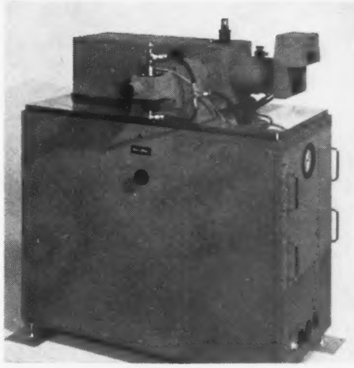
INFRARED HORIZON SENSOR
Barnes Engineering Co., Stamford, Conn.
Booth Numer 106

Designed for space vehicles, Series 13-160 horizon sensors are compact, sensitive, infrared scanning instruments which detect the sharp thermal discontinuity between the earth's atmosphere and outer space. They employ germanium-immersed thermistor detectors, making them sensitive to far-infrared wavelengths, but unresponsive to visible and near-infrared radiation, so that they detect only the earth's self-emitted radiation, and not that of reflected sunlight. Available in two models for use in either a three- or four-sensor vehicle control system, Series 13-160 sensors will establish a local vertical to within 0.1 deg accuracy, will sense pitch and roll errors relative to this reference axis, and will produce control signals proportional to the errors. These signals can be used in a reaction system to correct the vehicle's attitude, and in a readout system to measure its altitude. The sensors operate with equally high accuracy over an extremely wide range of altitudes, from the minimum at which orbits are possible, up to the 22,000-mi. altitude of 24-hr orbits. Though designed for use in earth satellites, they can be adapted to meet the requirements of vehicles orbiting about the moon or other celestial bodies.
Key number 308


Package design of Weld-Pak® module


Welding interconnections on Weld-Pak® module


Raytheon Weld-Pak® logic stick

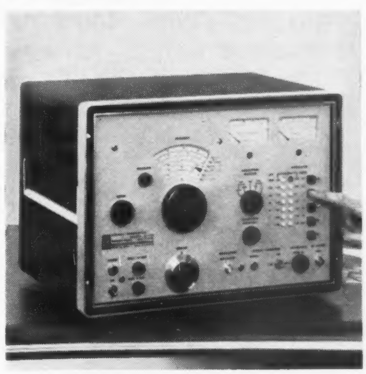


TIME RESOLVING SPECTROGRAPH
Beckman & Whitley, San Carlos, Calif.
Booth Number 310

This is a spectrographic dispersion unit, combined with a sweeping image photo recorder acting as a wavelength selective detector. The device can record temperature measurements of events occurring at temperatures from 2000 to 100,000 K, black-body temperature equivalent, and varying in time down to 3×10^{-9} sec. It is an all reflection-optics system which can be operated under vacuum from the ultraviolet wavelength to the infrared ranges. Measurements accurate to within ±10% in the 100,000 K region are obtained by relating the recorded film densities to a film density previously obtained from a source of known radiation and temperature. The unit is now used in investigations of spectral distribution of the distribution of light emitted in explosive research and studies in the composition of molecular species, and may eventually be employed in hypersonic testing, aerodynamic heating, gas dynamics, shock tube studies, and other fields requiring the measurement and analysis of high-speed radiated transients or concentration temperatures.
Key number 309

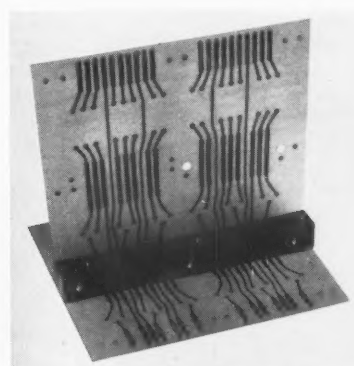
NEW TEST INSTRUMENTS
Borg-Warner Controls, Div. of Borg-Warner Corp., Santa Ana, Calif.
Booth Number 144

Development of a newly designed line of precision meters and signal generators to supplement its established line of R-F equipment has been announced by Borg-Warner Controls. Included in the new line are vacuum-tube voltmeters, volt-ohm meters, R-F power meters, VSWR Indicators and signal generators spanning the spectrum from HF to SHF. All instruments feature clean, functional styling with no unsightly bulges or protrusions. The modern, low-silhouette horizontal packaging includes recessed, fold-away handles for easy carrying, storing, or stacking. A wrap-around plate, mounted flush with the case, permits safe, convenient storage for the power cord. Front panel design on all instruments features recessed, easy-to-read meters, and all controls well-spaced and grouped for easy accurate use. Complete specifications and technical information are available from Borg-Warner Controls, P. O. Box 1679, Santa Ana, Calif.
Key number 310



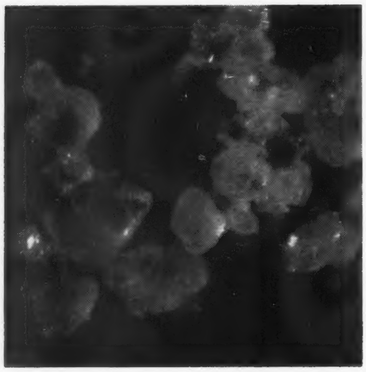
RF SIGNAL GENERATOR
Borg-Warner Controls, Div. of Borg-Warner Corp., Santa Ana, Calif.
Booth Number 144

RF Signal Generator G-101 operates in the 60 kc to 65 mc range with constant output over the entire frequency range, and gives constant modulation level and continuous AM monitoring with pushbutton attenuator system that gives fast, accurate signal light readout. It currently is being used in the laboratory and field in multi-purpose RF Test Equipment, and should eventually find applications in quality control departments and incoming inspection and standard laboratories throughout the country.
Key number 311



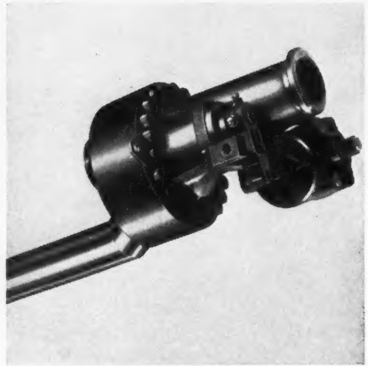
PRINTED CIRCUIT CONNECTOR
Brown Engineering Co., Inc., P.O. Drawer 917 Huntsville, Ala.
Booth Number 207

The BECON printed circuit connector is a unique improvement in the electrial and mechanical connection of printed circuit boards. It is designed to eliminate connector wiring, soldering, and drilling the board for pins. This new design uses two major components—a Diallyl Phthalate mechanical body and fixture heat-treated electrical connectors of gold-plated beryllium copper. The mechanical body also serves as a receptacle for the electrial connectors. In use, the spring action of the beryllium-copper electrical connectors exert force against the pick-up points on the printed circuit boards. A positive connection is made when the mechanical connector is fastened to the boards.
Key number 312



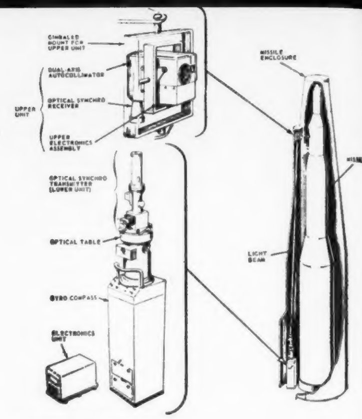
NITRONIUM PERCHLORATE
Callery Chemical Co., Callery, Pa.
Booth Number 546

Nitronium perchlorate is a high density, energetic solid oxidizer for rocket-propellant formulations. With many fuels, nitronium perchlorate gives higher performance than most of the present solid oxidizers. For complete details on this product, visit us at our booth or write to the Defense Products Dept. at the above address.
Key number 313



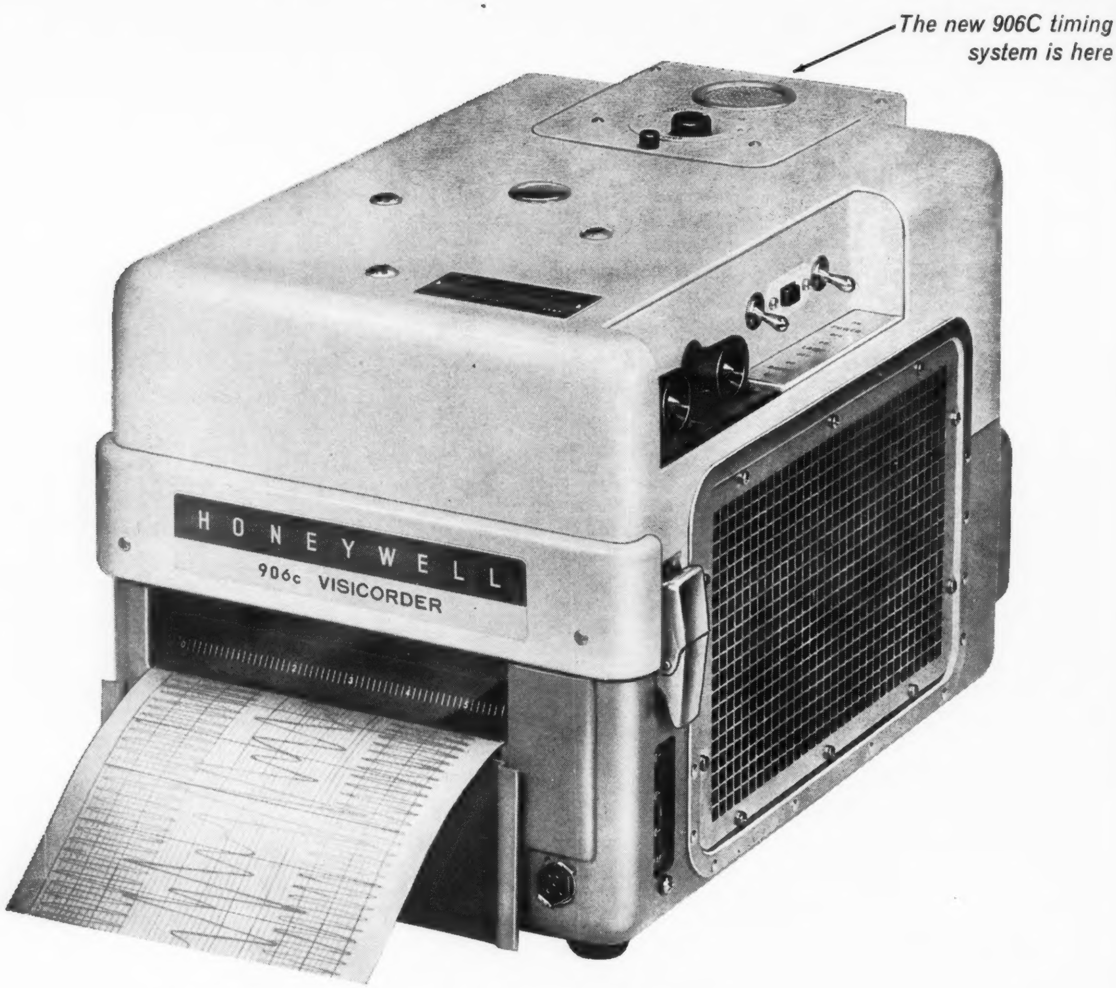
ATOMIC REACTOR WATER VALVE
Chandler Evans Corp., Div. of Fairbanks Whitney Corp., West Hartford, Conn.
Booth Number 238

Designed for use in General Electric's new NPR reactor now being constructed at the AEC Hanford plant, Chandler Evans' WV-16 valve is one of a series engineered by the company for operation in a radioactive environment. Now in volume production, these valves are used for water flow control in the reactor's recirculating water cooling system. With 2-in. diam full-flow ports, each valve can provide for flow of demineralized water up to 400 gal per min at temperatures to 600 F and pressures to 2000 psig. An air-operated actuator is an integral part of the valve assembly. The unit lends itself to remote control using manually or electrically operated selector valves and can be supplied with a control system permitting adjustment of actuation time up to 2 min. The design can be scaled to handle larger or smaller flows and can be fabricated from materials compatible with corrosive fluids.
Key number 314



AIMING SYSTEM
Chrysler Corp., Missile Div., Detroit, Mich.
Booth Number 545

By means of this precise electro-optical orientation system for aiming the mobile Minuteman missile, true azimuth is transferred via a modulated polarized light beam to the missile platform to orient the guidance system prior to firing. The optical receiver orients to this beam and the true azimuth is transferred vertically to the elevation of the missile platform. A precise two axes autocollimator using modulated polarized light monitors azimuth of the guidance system, compares with the reference azimuth, and sends a correction signal to the missile. This new approach eliminates many normal optical problems such as air movement, vibration, temperature, response time, translation error, etc. The entire system is solid state with no moving parts. Variations of this system can be applied to precision noncontact measurements to one second of arc under adverse operating conditions. Future applications of the techniques developed may be used for space guidance and navigation.
Key number 315



What's *different* about the NEW 906C VISICORDER OSCILLOGRAPH?

At first glance you may see no difference at all. Just the same functional lines and compact size that you have come to recognize in the Visicorder.

They have not changed since 1956, when the Visicorder principle of oscillography made immediate readout of high frequency data possible for the first time.

Until now, all the improvements that have maintained the Visicorder's record of leadership have been internal:

—increased capacity to 14 channels
—higher frequency response (0-5000 cps)
—simultaneously recorded grid lines
—self-starting lamp for remote operation

But the 906C has a new feature you *can* see, (look carefully at the back of the case) and one that represents still another breakthrough; a built-in flash tube timing system which not only generates its own time base, but which can also be triggered *externally*. You can, in other words, use the 906C's timing system to record time lines simultaneously with data. Or you can trigger the timing circuit externally—either by supplying a pulsing voltage of only +10v into 20K ohms impedance, or simply by causing impedance to drop to 100 ohms or less through shorting-out or other means.

Thus your "time" signal may actually be an event marker related to shaft rotation, belt movement, or any other effect which might be more conveniently fed to the timing circuit than to a galvanometer.

(Owners of Visicorders 906, 906A, and 906B will be glad to know that only a *field-change* is necessary to economically and easily add this timing system to their instruments)

Write today for full information on the brand-new 906C Visicorder. Ask for Catalog HC-906C. Or call us at SKyline 6-3681, Direct Distance Dialing Code 303.

Minneapolis-Honeywell, Heiland Division
5200 East Evans Avenue, Denver 22, Colorado

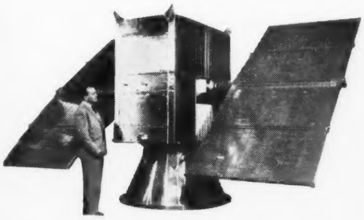
Honeywell
H First in Control
SINCE 1885

HONEYWELL INTERNATIONAL

Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

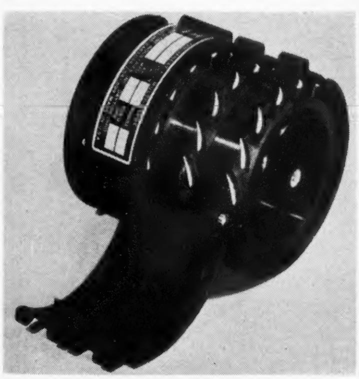
MINIATURE ZIP-LOC
Deutsch Fastener Corp., Los Angeles, Calif.
Booth Number 236

This miniaturized stressed panel-fastener is designed to carry high loads with minimum weight and size. It will support 1000 lb in tension and 5440 lb in double shear, despite its extremely small size. Miniature Zip-Loc's are being used on removable doors and panels in aircraft, missiles, and electronic gear.
Key number 316



ADVENT SATELLITE
GE Missile & Space Vehicle Dept., Philadelphia, Pa.
Booth Number 365

The Advent communications satellite will be part of Project Advent, a worldwide military communications satellite system being developed for the services by GE-MSVD. Advent will involve three microwave communications satellites traveling in 24-hr synchronous orbits above the equator. The system will receive, amplify, and relay signals from the earth. Advent will have extensive channel capacity. High-speed radio teletype and voice broadcasts will be transmitted simultaneously. Power for Advent's 28-v electrical system will be derived from silicon photovoltaic solar cells. When the vehicle is in the earth's shadow, power will be supplied by nickel-cadmium batteries.
Key number 317



MULTISTAGE BLOWER
Globe Industries, Inc., Dayton, Ohio
Booth Number 135

A new 3-in.-diam blower uses compressor staging principles to deliver 39 cfm of air against system resistance of 14.0 in. H_2O. Called STAX-3-FC, the unit is designed for use with heat exchangers, transistor cold plates, and crowded electronics enclosures. Low specified speed ($N_s = 15{,}000$) indicates use in place of large radial wheel centrifugal blowers rated up to 1/4 hp. STAX-3-FC operates on 200 v.a.c. 400 cycle, but other power variations can be supplied. Propellers, guide vanes, and housing are die cast and black anodized. All rotating parts are dynamically balanced. Units are designed to meet MIL specs. Mounts by clamping to servo ring. One, two, or three compression stages may be mounted in the same housing; unit measures 3-in. diam x 3-in. long, and weighs 29 oz. Limited number of prototypes in process for fast delivery. Descriptive Bulletin X-1590 is available.
Key number 318


WATCH THIS SPACE
In a moment a new satellite will streak into view. Bell Laboratories may help guide it into orbit, for few are so eminently qualified in the science of missile guidance. Bell Laboratories' Command Guidance System has guided such trailblazers as Tiros and Echo into precise orbits. The same system will guide more new satellites into predetermined orbits as Bell Laboratories continues pioneering in outer space to improve communications on earth.
BELL TELEPHONE LABORATORIES
World center of communications research and development

ATMOS SOUNDING ROCKET

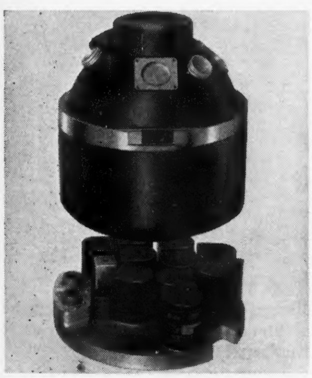
B. F. Goodrich Aerospace and Defense Products, Akron, Ohio.
Booth Number 273

The Atmos rocket is being developed for atmospheric sounding missions under a B. F. Goodrich-sponsored program. It is designed for lifting a 6.5-lb instrumented payload to an altitude of 280,000 ft; however, payloads of other configurations within the weight range of 3.0 to 15 lb will be lifted to an altitude range of 200,000 to 330,000 ft. The rocket consists of a solid-propellant motor, separation device, parachute package, nose cone, instrument package, stabilizing fins, and launcher. The motor employs a high-energy low-burning-rate solid propellant. The individual components are of the modular design that facilitates minor modifications to suit individual mission requirements. Field handling and ground-support equipment have been minimized through use of lightweight components and maximum factory assembly and checkout. The Atmos rocket is also intended for use as a staging motor, separation device, sled booster, retrorocket, and other applications.
Key number 319

FLEXIBLE INSULATION

Johns-Manville Corp., Industrial Insulation Div., New York, N. Y.
Booth Number 228

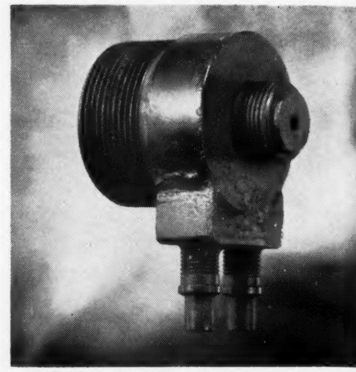
Min-K is a flexible blanket-type insulation suitable for folding, wrapping, and spiraling onto a variety of shapes. It has a thermal conductivity lower than the molecular conductivity of still air, a marked reduction of thermal conductivity with the reduction of pressure at higher altitudes, and a thermal diffusivity lower than ordinary materials weighing over five times as much. It offers a new approach to steady state and transient thermal problems requiring inherent performance and space and weightsaving features possible only with this material. Flexible Min-K is ideal for prototype and development work. It readily fits any geometrically developable shape and can be easily modified on the job. In blanket form, it lends itself to bonding, lamination with reinforced plastics, service coatings, and as a component of insulation systems. In tape form, it can be used for spiral winding on duct or pipe.
Key number 320



GUIDANCE, CONTROL SYSTEMS

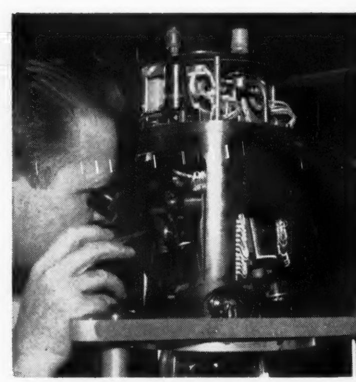
Kearfott Div.-General Precision Inc., Tarrytown, N. Y.
Booth Number 582

The company's products include various guidance and control systems currently used in missile and space-vehicle programs. These systems embody new concepts in inertial guidance, stellar inertial and optical techniques. Specific details cannot be discussed publicly concerning this equipment, but the company welcomes appropriate technical contacts.
Key number 321



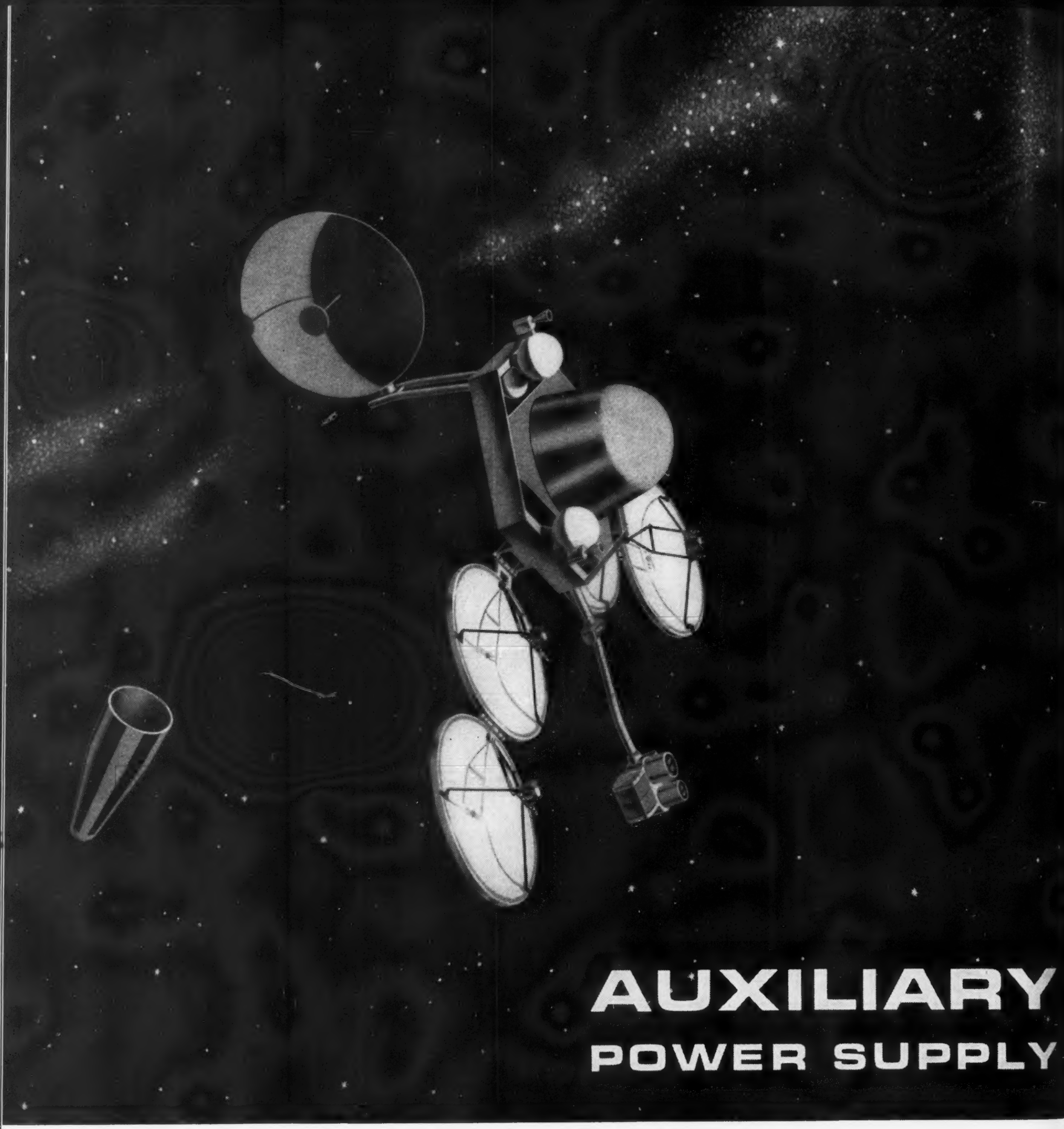
HI-TEMP SOLENOID
Walter Kidde & Co., Inc., Kidde Aero. Space Div., Belleville, N.J.
Booth Number 264

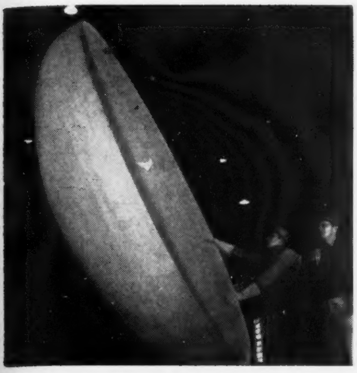
An on-off solenoid for use with gaseous or liquid valves has been developed and is capable of extended exposure of 1500 F. Operating at 1.2 amps and 28 VDC, the solenoid provides 8 lb pull at .010 in. gap. Forty-hour operating life at 1500 F has been proved. The solenoid was developed for use with control valving in applications where ambient temperatures range from 500 to 1500 F, such as in engine case and A/B areas, rocket engine controls, secondary injection valving, re-entry vehicle stabilization systems, nose cone controls, and in the high radiation and temperature conditions of nuclear reactors. As presently designed, adaptation to existing valving is possible. With modification, the principle may be tailored to newer concepts. Designs of complete assemblies are available at Kidde, as well as data sheets.
Key number 322



ASTRO TRACKER
Kollsman Instrument Corp., Subsidiary of Standard Kollsman Industries, Inc., Elmhurst, N.Y.
Booth Number 145

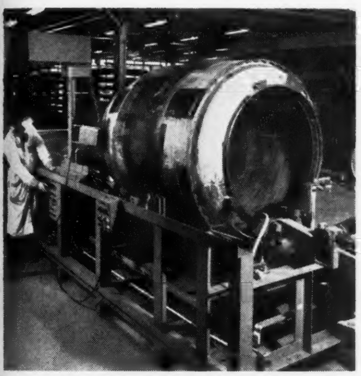
The KS-85 Astro Tracker is an automatic photoelectric device which provides accurate navigation information by tracking celestial bodies. The system provides more accurate true heading than other devices, is operational 24 hr a day at all latitudes and longitudes, contains automatic tracking to eliminate "human error," and may be remotely and permanently installed. The KS-85 and other Kollsman Astro Tracker systems are currently used in military and commercial jet aircraft, missile systems, and space vehicles. They also have wide application in surface and underwater navigation.
Key number 323





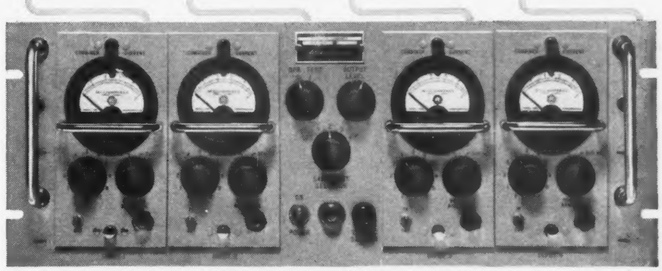
CLOSURES AND DOMES
Lukens Steel Co., Coatesville, Pa.
Booth Number 271

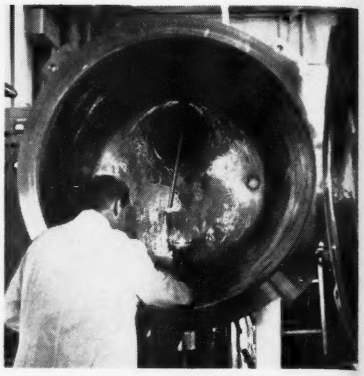
A new "spinning" technique now makes it possible to produce rocket motor heads up to 21½ ft in diam. These large heads are presently being used as domes and closures for the motors. Their versatility also makes them of interest for future space vehicles. Heads are produced from Lukens' own carbon, alloy, and clad steel plate, as well as from titanium, stainless, and other ferrous nonferrous metals. A color slide presentation illustrating the head forming operation will be featured at the Lukens booth.
Key number 324



INSPECTION SYSTEM
Magnaflux Corp., A Subsidiary of General Mills, Chicago, Ill.
Booth Number 259

The X-2395 Magnaglo unit provides complete inspection facilities for assembled solid-fuel missile chambers to disclose defects on inside and outside surfaces, as well as in stacks, skirts and bosses. After inspection, chambers are demagnetized automatically. The unit will inspect chambers up to 20 ft long and 67 in. in diam. Power pack supplies a magnetizing current of 10,000 amps, full-wave D.C., and sufficient A.C. for induced current fixtures and demagnetization. Output of the eight separate magnetizing circuits is regulated by five 8-point tap switches. A 30-point motor driven tap switch is used for demagnetization. The chamber rests in the unit in a horizontal position and is indexed on a set of power-driven rollers. Magnetization proceeds in a series of steps employing a central conductor, induced field fixture, and induced current fixture. The fluorescent magnetic particle bath is applied automatically.
Key number 325



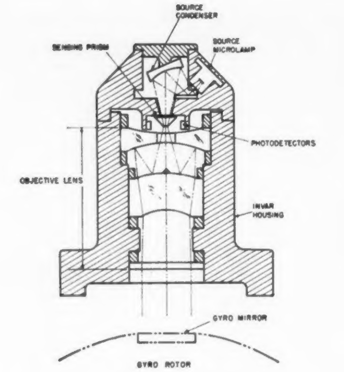


SPACE VACUUM LABORATORY
National Research Corp., Research Div., Cambridge, Mass.
Booth Number 528

This space vacuum laboratory is the only U.S. facility with 12 chambers and up to 50 cu ft in volume for simulating orbiting space environments beyond 500 mi. It achieves space vacuum of 10^{-10} torr (mm Hg), in combination with low ultraviolet radiation, thermal cycling, and load conditions. It enables research and testing of materials and devices for space use and in the investigation of such problems as friction, lubrication, heat transfer, tensile strength, emissivity, electrical conductivity. NRC space facilities have tested components for Midas, Samos, Tiros, Advent, Mercury, Nimbus and Ogo. This laboratory aids NRC's team in the design of major space chambers and development of spacecraft systems and materials. For information, contact Contracts Manager, National Research Corp., Cambridge, Mass.
Key number 326

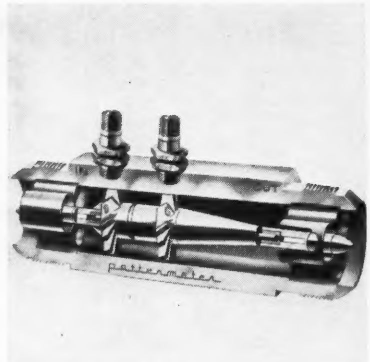
SAFE ARM DEVICE
Ordnance Associates, Inc., South Pasadena, Calif.
Booth Number 578

High-pressure safe arm devices, such as shown above, are capable of low order explosive ignition, and actuation, as well as high order detonation. These units, 2.5-in. long, 0.9-in. in diam, and only 2.8 oz, operate on 28 v power sources and require no auxiliary electronic equipment or special wiring. The safe arm devices contain an in line out of line system that may be visually as well as electrically monitored to determine the safe or arm position. The explosive portion is capable of withstanding 50,000 psi internal pressure. These units are available in any of the conventional all fire, no fire configurations. Should an accidental firing occur in the safe position, the output charge will not fire, and the visual window is blackened. In addition, the bridge wires show infinite resistance when fired. These safe arm devices are designed to operate under all normal squib applications with an increased margin of safety.
Key number 327



OPTICAL PICKOFF
Perkin-Elmer Corp., Electro-Optical Div., Norwalk, Conn.
Booth Number 123

The first ultra-miniature optical pickoff for alignment monitoring of new, advanced type of gyros weighs less than 9 oz. It permits precise alignment measurement, yet produces no significant torque on a gyro rotor. It uses the principle of autocollimation to eliminate inaccuracies inherent in standard electrical precession pickoffs. OPTAG (Optical Pickoff for Two-Axis Gyros) senses light improperly superimposed on the nose of a prism and feeds these error signals to the torquing motors of the gyro gimbals. Instrument sensitivity is better than one arc-second. It has an f/2.0 objective lens and a focal length of 0.60 in. OPTAG was developed by P-E for Astro Space Laboratories for application to an air bearing gyro mounting a flat mirror on its rotor normal to the spin axis. Other applications possible include use with magnetic, electrostatic, or other types of super-gyros.
Key number 328



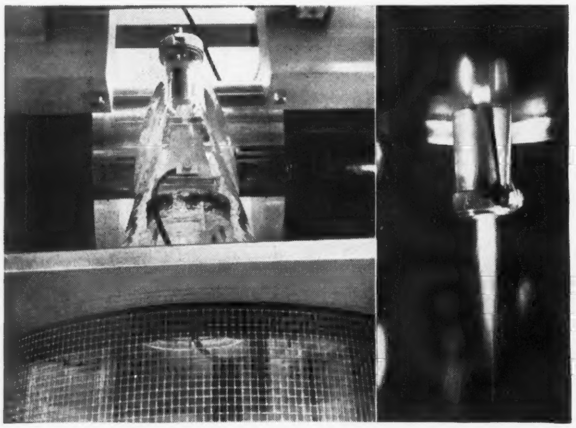
MASS FLOW METER
Potter Aeronautical Corp., Union, N.J.
Booth Number 153

The Pottermeter twin-turbine true-mass flow meter is made of stainless steel, has in-line mounting, and gives an electric output signal. The Series 3000 can be made from a wide choice of materials. Small, compact, and line size, and mountable in any attitude, it requires no outside power source. Operating experience has revealed successful fluid metering in the temperature range of —430 to +850 F. Linear response is available over a ten to one range. Rocket and missile companies use the meter to measure liquid-rocket propellants on a true mass basis, and it may be used in the petroleum pipeline industry for in-plant process control.
Key number 329

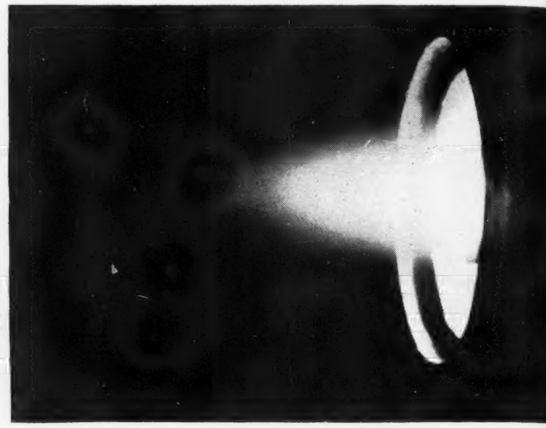
PYROFUZE®
Pyrofuze Corp., Affiliate of Sigmund Cohn Corp.
Booth Number 623

Pyrofuze is a bimetallic composition, the elements of which alloy violently at 650 C, exothermically resulting in deflagration without support or oxygen. Pyrofuze exhibits extreme environmental insensitivity can only be initiated by heat (650 C), and is gasless and shockless. Adapting to manufacture in extreme configurations, is utilized in squibs, matches, detonators, etc., for direct ignition of solid and liquid propellants. It represents a new approach in the area of destruct mechanisms, separation devices, and destructible members. Its versatility is seen by its application from fusing to fuzing.
Key number 330

Key number 76 ⟶



Lab close-ups show G-E plasma accelerator on test. Engine thrust from the generator (inset at right), which exits into the caged enclosure (left), is accelerated by passing through a field maintained by the large magnets on either side.



Arc jet engines such as the one shown in operation here have been successfully run in G-E laboratories for several years. Present state-of-the-art at General Electric indicates that an arc jet can be ready for flight test by late 1962.

G.E. Tests Electric Engine Types for Space Missions

A line of electrical space engines whose diverse capabilities can provide vehicle speed, attitude, and direction for a wide variety of space missions is under test at General Electric.

Three basic engine types—arc jet, plasma accelerator, and ion engine—constitute the line. Models of each type are currently in operation at the Company's Flight Propulsion Laboratory Department in Cincinnati.

Under NASA contract, G.E. has test-demonstrated a 30KW, a-c powered arc jet engine that develops one-half pound of thrust. Performance exhibited on test earmarks it as useful for space missions such as lunar transfers, transfer to stationary satellite orbits, and placing communication satellites in precise orbital position.

Plasma accelerators, second in G.E.'s line of electrical space engines in terms of specific impulse, are in early research stages at the Cincinnati plant. A continuous flow device, which has already been bench operated, shows promise of good performance in the higher power ranges at specific impulse rates which look attractive for lunar missions.

Ion engines, whose specific impulses can theoretically rise to several hundred thousand seconds, are expected by G.E. to prove ideal for long duration space trips such as interplanetary missions. Since 1958, when General Electric engineers ran one of industry's first ion engines, continuing research and development has produced a variety of improved configurations.

A number of component development programs are also contributing to G.E.'s ion engine program. Among them are studies investigating methods for generating and accelerating ions; determining electrical conductance in cesium vapor; developing a system for feeding cesium propellants to ion engines; and neutralizing electrical space charges.

Typical of ion engines on test at General Electric is this advanced design XE-701-4 model, whose efficiency was theoretically doubled with a new computer program.

NEW STUDIES TO EXPLORE SYSTEM COMPATIBILITY

Studies are under way at the G-E Flight Propulsion Laboratory Department to pinpoint future problems of matching electrical propulsion systems to space power generation plants. G.E.'s intention is to produce the needed answers *before* power or propulsion system development gets into expensive hardware stages.

A basic element of the studies will be to identify "internal" compatibility problems of electrical space systems. For example, it appears that arc jet engines, to fulfill long-life requirements, may require voltage input somewhat higher than considered optimum for generator design. Where, then, should a total system compromise be established?

VARIABLES TO BE INTEGRATED

G.E.'s answers to this and other typical questions will integrate a vast number of "internal" variables in engine and turbogenerator design, extending when necessary into the areas of turbine and boiler flow control, and reactor control methods.

Studies will be heavily influenced by consideration of mission duty cycles anticipated for future space power/propulsion systems. As a typical example, extended periods of engine-off condition during space travel forces a study of power dumping methods. Should the power system's total output be modulated by reactor and turbine control? Or should the power be fed into dummy loads, maintaining the powerplant at full rated conditions?

IMPORTANT INSIGHTS FORESEEN

Answers to such questions, believes General Electric, will provide badly needed insight into means of optimizing soon-to-come power/propulsion systems for each envisioned mission. Broad knowledge to be gained by the G-E studies center around two fundamental questions:

—What can be realistically done with present technology?
—What areas will require additional applied research to make needed systems practical?

With accelerated space schedules tending to compress development cycles, G-E management believes that the answers attained—and questions anticipated—by these studies will permit considerable savings in the nation's future space power/propulsion system development costs.

NEWS

A report about progress in research and products from the Flight Propulsion Division of the General Electric Company

SPECIAL REPORT

POWER/PROPULSION FOR SPACE

New Computer Program Speeds Ion Engine Design Solutions

Ion engine configurations can now be quickly and accurately evaluated by a new digital computer program developed at G.E.'s Flight Propulsion Laboratory Department.

In a typical project, the computer system recently evolved a new ion engine configuration that is expected to have double the efficiency of its forerunner. Design of the new engine, designated the XE-701-4, was quickly refined by the computer so that direct interception of the ion beam with the electrodes is virtually eliminated. (Such beam interception reduces engine life and efficiency, both extremely important for space missions.)

CONTRACTED BY NASA

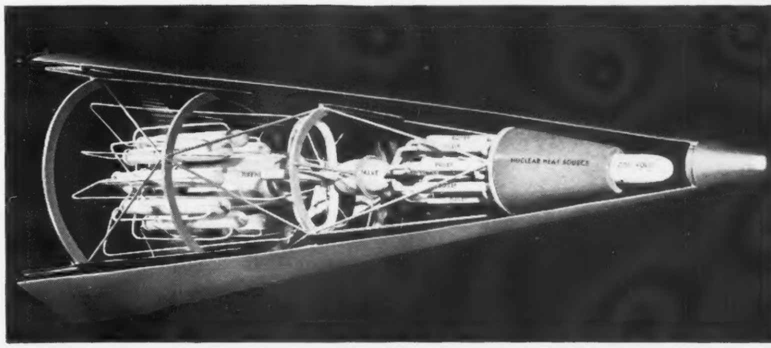
The fully automated computer program was created under contract with NASA's Marshall Space Flight Center.

G.E.'s program uses four computational links and three display links for monitoring analysis progress. A coordinate mesh placed over a cross-sectional engineering drawing of the engine defines all evaluation points in the ion beam and electrode regions.

Once this programming has been set up, each of the 100 to 200 sweeps by the computer through a 4000-point mesh requires less than two seconds.

Comparable times are required to compute such factors as ion accelerating forces and space charge densities. The program is reiterative in that previous runs are repeated until desired accuracy is achieved.

Speed of a typical analysis is such that a complete evaluation of a new engine can be completed in less than an hour, including analysis of initial ion velocities and space charge.



Typical of nuclear space power systems now under study at General Electric is this 300 kilowatt package. Heat from the reactor (right) is converted to electrical energy by the turbine-generator. Waste heat is dispersed into space by a radiator located beneath the vehicle's skin at the larger end of the enclosure.

New Facilities Boost Space Power Research

A 50KW, 1600°F alkali metal test facility was placed in operation recently at General Electric's Space Projects Laboratory in Cincinnati, Ohio.

Its initial research projects will investigate heat transfer characteristics of boiling and condensing alkali metals, which are used as working fluids in nuclear turbogenerators for space.

Several larger, more versatile metal test facilities are in various stages of planning and construction at the Laboratory. Within a few weeks, a 300KW facility designed to operate at 1850°F will be completed. Following in the near future will be a 100KW, 2200°F unit and a 3000KW, 1850°F unit.

TYPIFY G-E GROWTH

These facilities typify a growing research complex at G.E.'s Flight Propulsion Laboratory Department here, where development of large electrical power generating systems for space has been under way since early in 1957.

General Electric is presently focusing research on nuclear turbogenerator systems which combine a nuclear reactor heat source and turbine-driven electrical generators. Alkali metals such as potassium and sodium are used as working fluids. Such systems will provide power for electrical propulsion, electronic equipment, and life support.

Present research includes various activities in basic technology, component development, and system analysis.

HEAT TRANSFER STUDIED

In a program under NASA contract, the Laboratory is conducting boiling and condensing experiments on potassium and sodium to establish heat transfer characteristics and provide design data for space power system heat transfer components in the 1200° to 2200°F temperature range.

Another NASA-supported program entails demonstrating a potassium-vapor turbine applicable to large space power systems. In the 3000KW facility now under construction, two turbine stages of an 1800°F, 500KW turbine will be operated on wet potassium vapor for more than 2000 hours.

These and several other research programs are being coordinated by General Electric to have a space power system—having minimum risk and maximum reliability—ready when the call comes for its integration into future power/propulsion systems.

G-E ARC JET SUCCESSFULLY RUN ON A-C POWER

An important stride in arc jet technology was announced by General Electric recently after the Company successfully developed and ran a 30KW engine that operates on alternating current.

The new engine has met thrust and specific impulse levels specified by NASA, which granted the development program contract.

Initial work with arc jet engines throughout industry was concentrated on d-c powered designs because of their relative simplicity. But space power generation systems currently under development tend toward high frequency, multi-phase alternating current because it permits lighter-weight systems.

A-C APPROACH ELECTED

Despite many problems inherent to a-c arc jet development, G.E. elected to follow this approach. It recognized its important value in eliminating rectifiers and other weighty components from future space propulsion systems.

A key problem in development was the question of ignition. While d-c arc ignition takes place only once, it was suspected that with three-phase a-c the arc might be extinguished and that there would be problems of re-ignition.

COMPUTER PROVES SOLUTION

However a computer program, supported by later experiments, proved that while only two electrodes would be conducting at any one time and the third arc would be extinguished, an inherent voltage transient would insure re-ignition of the extinguished arc.

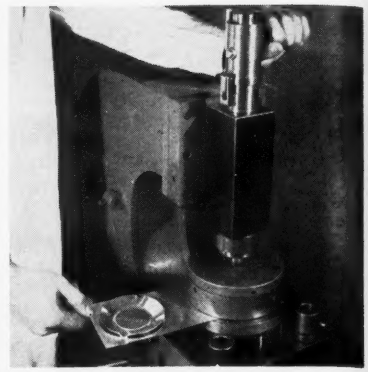
Under another program for NASA, General Electric is determining the most attractive missions for this a-c arc jet engine. Studies are centering around lunar transfers, transfers to stationary orbits, and installation of communication satellites in precise orbits.

SEND FOR FREE BROCHURE

For more information on General Electric's space power and propulsion program, just send a card to General Electric Company, Section 110-07, Schenectady 5, New York, and ask for a free copy of GED-4442, "Electric Power/Propulsion for Space."

Progress Is Our Most Important Product

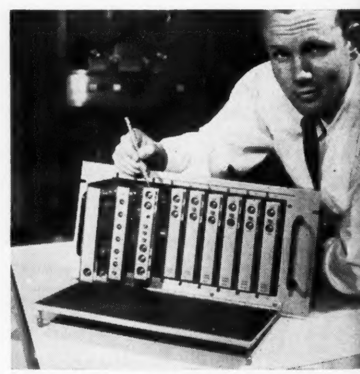
GENERAL ELECTRIC



PACKAGED POWER
Ramset Fastening System, Winchester-Western Div., New Haven, Conn.
Booth Number 124

Packaged Power is a prepackaged explosive energy source capable of doing large quantities of work in scientific, commercial, and industrial applications. The energy from Packaged Power is easily controlled and directed through various system designs. Its many features include compactness and high energy storage; instantaneous response; and a high level of reliability and efficiency. Packages of propellent power are being used to separate satellite stages, to eject seats from airplanes, punch clean holes into intractable metals, start jet engines, splice cables, drive studs into concrete and steel, and to form new, exotic metals into bizarre and unusual shapes. The ability and potential use of Packaged Power to perform useful work in an endless variety of applications is limited only by the imagination.

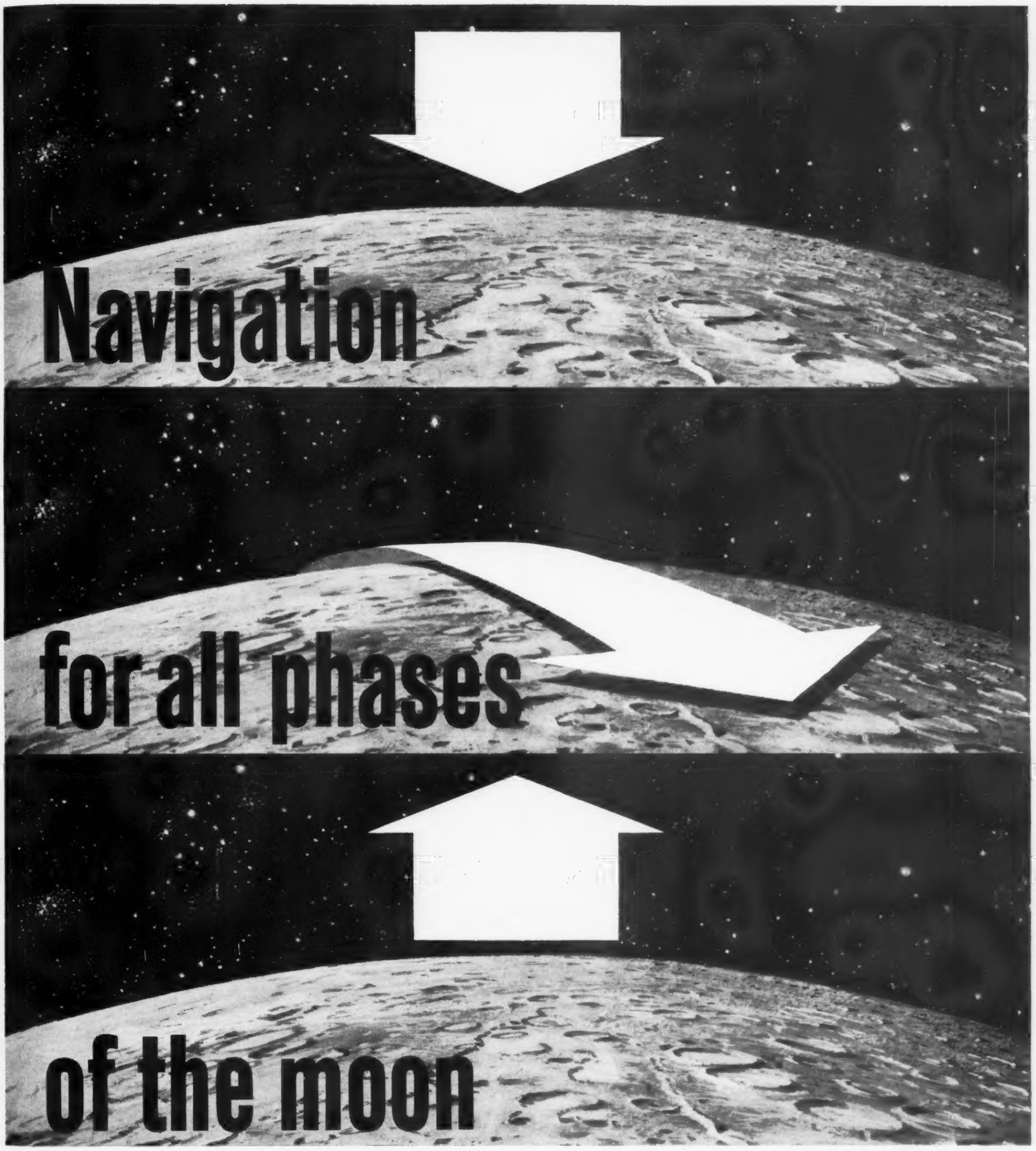
Key number 331



ANALOG-TO-DIGITAL CONVERTER
Raytheon Co., Communications & Data Processing Operation, Waltham, Mass.
Booth Number 395

Raytheon's new high-speed A to D converter was designed to be used asynchronously with a radar system. Core buffers after the output circuit of the converter store incoming data at the high peak rate and apply it at a much lower average rate to magnetic tape. Output data are later analyzed in computers. Upper limit of sampling rate approaches 10-million samples per second with 10-bit accuracies. Plug-in modules and printed circuits provide stability and reliability; 98% of its transistors are of two types only. The unit is $8^3/_4$ in. high by 19 in. wide by 10 in. deep and weighs about 20 lb. The AD-50A is being used by Johns Hopkins and certain military agencies. Its many uses include research instrumentation, input for high-speed computers, conversion for radar systems, and for encoding and encrypting video signals.

Key number 332



"Manned lunar probe" means a successful round trip . . . and poses a host of problems. Among others, navigation. To get to the moon or a planet, move on its surface, and return to earth is a full-scale systems requirement, calling for the highest order of navigation, guidance and control sophistication.

In all phases of space navigation — particularly the tougher ones of rendezvous guidance, mid-space station assembly, movement over the surface of planets, return vehicle launch, re-entry and landing — the Sperry Rand Systems Group offers a maximum team capability.

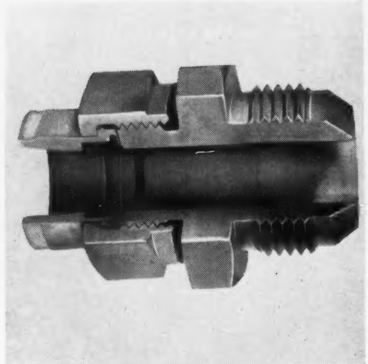
This capability includes deep space tracking radars, rendezvous, orbital and mid-course injection nets, space command and control centers, attitude control systems, real time data processing, and sophisticated recovery systems to guide a vehicle through the difficult final approach, dissipating its speed and maneuvering it to a precise landing site. Other systems include optical communications and sensing, pilot displays and controls, auxiliary power and automatic checkout.

Visit Sperry Rand's Booth 330 at the Space Flight Report to the Nation, New York Coliseum, October 9-15.

SPERRY RAND SYSTEMS GROUP

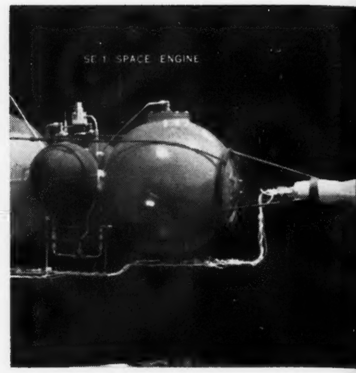
PLASMA PINCH ENGINE
Republic Aviation Corp., Plasma Physics Laboratories, Farmingdale, N. Y.
Booth Number 195

The plasma pinch engine presently being developed by Republic accelerates a plasma to provide thrust for use in propulsion, stabilization, and control of space vehicles. Demonstration of the basic principle of pinch initiation led to the design and fabrication of a prototype laboratory test engine. Present engines are operating at thrust levels from 0.001 to 0.01 lb of thrust and a specific impulse of 700 to 9000 sec. Power for the engine in space application will be supplied initially by batteries rechargeable from solar cells, but future systems will utilize a direct conversion nuclear electrical source. The proven reliability, simplicity, and advanced state of the engine will result in early application in space systems.
Key number 333



DYNATUBE
Resistoflex Corp., Roseland, N.J.
Booth Number 602

A high-temperature, high-pressure rigid-tube coupling with a superior seal, Dynatube maintains its seal under conditions of vibration, shock, pressure overloads, pulsing action or temperature variations. It is leakproof and is not subject to torquing difficulties although size and weight are reduced. Seal is maintained over extremely wide minimum and maximum tightening torques. Dynatube provides absolute dynamic sealing for all liquids and gases up to 700 F, and 1000 F for certain applications. It remains leakproof under cryogenic conditions, and is capable of handling 5000 psi helium. Dynatube is now used to replace standard AN tube couplings.
Key numebr 334



SE-1 SPACE ENGINE
Rocketdyne, a Division of North American Aviation, Inc., Los Angeles, Calif.
Booth Numbers 129, 130, 147, 148

A company-sponsored program has resulted in a flight-weight, test-bed space engine system that is being used to develop system and component features required for typical space-propulsion systems. The system incorporates space-application features such as long storability, positive propellant expulsion, fast response, uncooled thrust chambers, cold-gas pressurization, all-welded or brazed assembly, space-environment capability, and proved reliability. Nitrogen tetroxide and hydrazine propellants are used with altitude ignition at a thrust of 50 lb and a chamber pressure of 150 psia. Test demonstrations have resulted in 22-min-duration ablative thrust chamber tests, with 93 ignitions per second response. Advanced components are under development to incorporate into system tests. The test results are applicable to space attitude control and maneuvering engine missions.
Key number 335

Key number 79

FOR MORE DETAILS

The editors of ASTRONAUTICS provide the attached cards for your convenience. For additional information on products and services in this issue, simply write in the key number(s) [printed adjacent to the product information or advertisement].

ARE YOU AN ARS MEMBER?

The qualifications for membership appear on the reverse side of this page. Please fill out the attached card and mail.

Name__________

Title (or Position)__________

Affiliation__________

Street__________

City__________ Zone____ State______

ARE YOU A MEMBER OF THE AMERICAN ROCKET SOCIETY? YES ☐ NO ☐

Fill in the key numbers

____ ____ ____ ____ ____ ____

Name__________

Title (or Position)__________

Affiliation__________

Street__________

City__________ Zone____ State______

ARE YOU A MEMBER OF THE AMERICAN ROCKET SOCIETY? YES ☐ NO ☐

Fill in the key numbers

____ ____ ____ ____ ____ ____

Please send an application for__________ (member grade) membership in The American Rocket Society to:

Name__________

Title (or Position)__________

Affiliation__________

Street__________

City__________ Zone____ State______

Degree(s)__________ Year______

How long in astronautics field?__________

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit No. 1234, New York, N. Y.

— Postage Will Be Paid By —

AMERICAN ROCKET SOCIETY
500 FIFTH AVENUE
NEW YORK 36, N. Y.

READER SERVICE DEPT.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit No. 1234, New York, N. Y.

— Postage Will Be Paid By —

AMERICAN ROCKET SOCIETY
500 FIFTH AVENUE
NEW YORK 36, N. Y.

READER SERVICE DEPT.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit No. 1234, New York, N. Y.

— Postage Will Be Paid By —

AMERICAN ROCKET SOCIETY
500 FIFTH AVENUE
NEW YORK 36, N. Y.

MEMBERSHIP DEPT.

MEMBERSHIP

All persons professionally engaged in science or engineering relating to rocketry and astronautics are eligible for membership and will be assigned grades commensurate with educational attainment and with professional experience. Applications for admission to, or transfer from, one grade to another will be reviewed by the Membership Committee or its authorized representatives.

Persons holding Bachelor's degrees in science or engineering from accredited universities, colleges or technological institutes after four or more years of study, are deemed to have four years of professional experience.

Senior Members

Shall be professional persons of at least ten years experience in science or engineering in or related to rocketry and astronautics who have, by above average performance in at least four of those years, attained distinction in their fields. Such performance is defined as one or more of the following: 1) publication of important original scientific papers, books or inventions; 2) contribution to the welfare of scientific or engineering professions; 3) accomplishment of important scientific or engineering work; 4) direction of important engineering or scientific projects. The Senior Member grade is the highest grade of membership for which application may be made. Applicants must be recommended by three persons, two of whom must be Senior or Fellow Members.

Members

Shall be professional persons with at least six years experience in science or engineering in or related to rocketry and astronautics who have demonstrated competence in their fields. Applicants must be recommended by three persons, two of whom must be of the Member grade or higher.

Associate Members

Shall be persons having professional activity or interest in fields in or related to rocketry and astronautics. Applicants must be recommended by three persons, two of whom must be of Associate Member grade or higher, except that Student Members, upon completion of their education, are automatically eligible for Associate Member grade without additional recommendations.

Student Members

Shall be undergraduate or graduate students, under 28 years of age, who are in full time attendance at accredited universities, colleges, or technological institutes.

ing
m-
ith
ce.
ade
tee

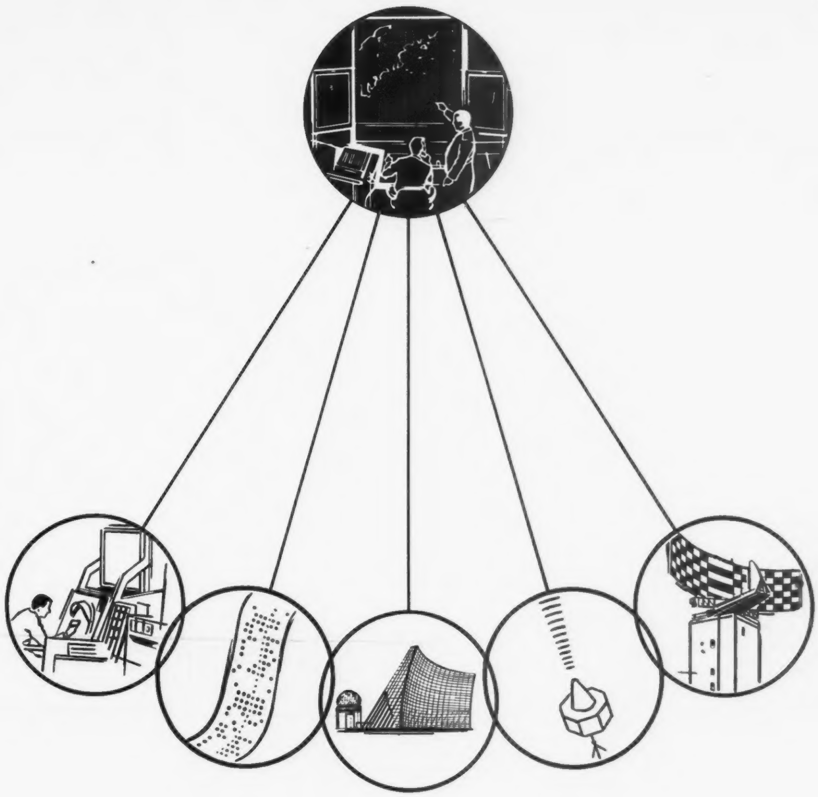
er-
cal
to

eri-
nd
at
ds.
ow-
rs,
en-
of
m-
ber
pli-
by
ow

eri-
nd
eir
ns,

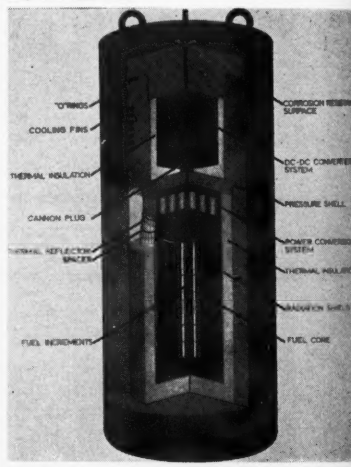
in
nts
ust
tu-
are
out

28
ted



CREW-ESCAPE SPACECRAFT
Rocket Power, Inc., Mesa, Ariz.
Booth Number 435

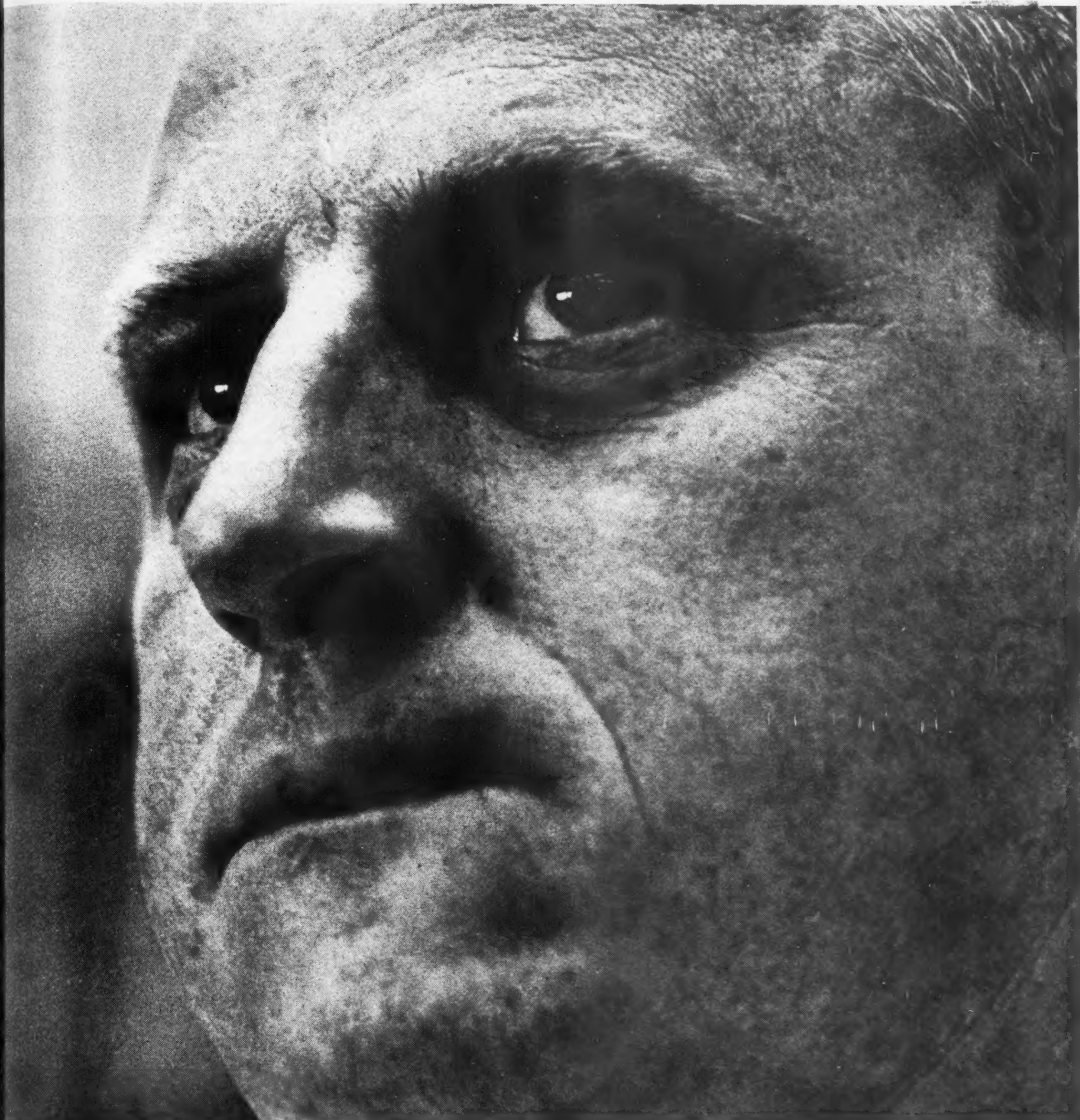
A solid-propellant-actuated system developed jointly with General Dynamics/Convair provides safe crew-escape capabilities at supersonic speeds and high altitudes. Built like an aerial toboggan, the vehicle provides a smooth aerodynamic shape for stable free flight and minimum shock to the occupant. Powered entirely by solid propellants the system includes three cartridge-actuated linear thrusters for elevating and rotating the seat-vehicle and dual rotary actuators for positioning the crewman and erecting the windshields. It includes two 8-ft telescopic stabilizing booms and four breakaway bolts. Finally, a dual-nozzle rocket motor provides propulsion for the free flying vehicle. On-board oxygen and global survival kit are included. Now being installed on all Convair Supersonic F-106 fighters, the system is being considered for orbital and lunar spacecraft.
Key number 336



THERMOELECTRIC GENERATOR
Royal Research Corp., A Subsidiary of Royal Industries, Inc., Hayward, Calif.
Booth Number 598

Under development for the Office of Isotopes Development, Atomic Energy Commission, this Cesium-137-fueled generator is designed to operate continuously for 3 to 10 yrs at a power output of 5 watts and 12 v. Now in final hardware phase, the generator consists of five components: Aluminum outer shell that will withstand pressure to 21,000-ft ocean depth, tungsten radiation shield, DC-DC converter, and power-conversion system and fuel-core complex. Nuclear decay heat produced by the fuel core is confined to the shield, which converts both the beta and gamma rays to heat. Past devices have utilized only beta particle energy. The shield conducts heat to the power-conversion system where a highly efficient thermocouple array converts the heat into electrical energy. The latter then passes through the DC-DC converter, which filters out voltage peaks and amplifies less-than-5-v load voltage to 12 v D.C. The generator is designed for powering seismological equipment at great ocean depths but is readily adaptable for use in any natural environment. Generators of greater capacity will become available in the near future.
Key number 337

Do you share his driving determination to know?



An unsolved problem is a nagging challenge to him. The word "impossible" is an impertinence.

Are you cut from the same cloth as this man? Then come to Northrop where you can work in the fringe of the future on such projects as space guidance and astronertial navigation systems, aerospace deceleration and landing systems, magnetogasdynamics, in-space rescue, repair and refueling techniques, laminar flow control, automatic test equipment and world-wide communications systems.

More than 70 such programs are now on the boards at Northrop, with many challenging problems still to be solved, and new areas of activity constantly opening up for creative research. Whatever your specialty, drop us a line now if you want to find out more about the Northrop challenge.

NORTHROP

NORTHROP CORPORATION, BEVERLY HILLS, CALIFORNIA
AN EQUAL-OPPORTUNITY EMPLOYER

URGENT:

SILENCE THE "ECHO" IN SATELLITE COMMUNICATIONS!

Every day our scientists and engineers strive to solve the critical problems of turning space vehicles into useful tools for communications.

Recently, they designed and produced an electronic device which *does* solve one of these problems—the echo. Without an echo suppressor, voice communications via satellites would be unintelligible. The new device completely silences echoes while one person talks and, just as important, reduces to unnoticeable levels the echoes when two people converse. As a result, one of the biggest obstacles to using satellites for global conversations is now removed.

The echo suppressor—when combined with ultra-reliable solid state receivers and transmitters plus the antenna systems for space communications already developed by GT&E scientists—makes entirely feasible a high-altitude active repeater satellite system that would operate in synchronous orbit with the earth's rotation. With such a system, only three satellites will be needed to provide world-wide communications!

By working in such advanced areas as satellite communications, the scientists and engineers of the General Telephone & Electronics corporate family contribute to the nation's progress. The vast communications and electronics capabilities of GT&E, directed through Sylvania Electronic Systems, can research, design, produce, install and service complete systems. These include the entire range from detection and tracking, electronic warfare, intelligence and reconnaissance through communications, data processing and display.

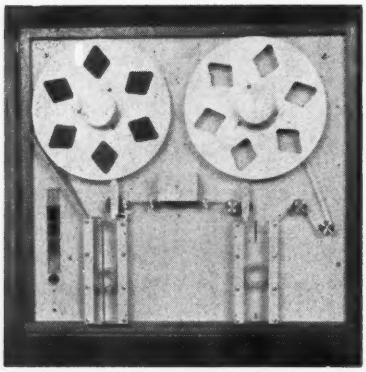
That is why we say—the many worlds of defense electronics meet at Sylvania Electronic Systems, a Division of Sylvania Electric Products Inc., 40 Sylvan Road, Waltham 54, Mass.

GENERAL TELEPHONE & ELECTRONICS

Total Communications from a single source through

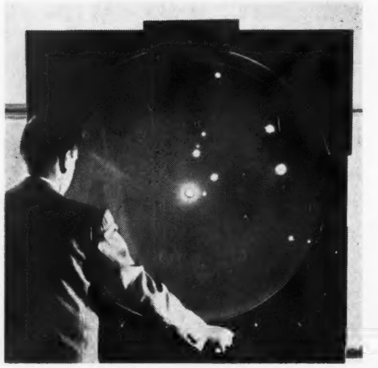
SYLVANIA ELECTRONIC SYSTEMS

Including: Automatic Electric • Electronic Secretary Industries • General Telephone & Electronics International General Telephone & Electronics Laboratories • Leich Electric • Lenkurt Electric • Sylvania Electric Products



TAPE TRANSPORT
Schonstedt Engineering Co., Silver Spring, Md.
Booth Number 159

The Model TSS-1 Tape Transport is a seven-channel recorder which has a tape speed of 0.1 in. per sec. The transport provides for a 40 db dynamic range of fm recording without the use of electronic compensation. The TSS-1 is designed for $10^1/_2$ in. reels of $^1/_2$ in. tape. The very low wow and flutter of the tape travel is achieved in part by isolating, from the critical part of the tape path, disturbances produced by the operation of the supply and takeup reels. To do so, the supply and takeup reels are independently and intermittently operated. The transport is used for recording low-frequency time-variations of the earth's magnetic field and may be used for recording low-frequency signals produced by other phenomena.
Key number 338

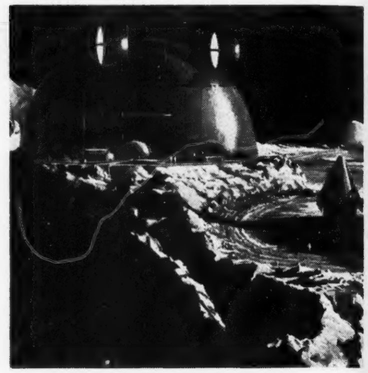


CLASSROOM PLANETARIUM
Scientific Industries, Inc., Burbank, Calif.
Booth Number 202

The "Copernican" Classroom Planetarium is a visual analog computer for solving and demonstrating problems in celestial navigation and orbital mechanics in the solar system. The Planetarium demonstrates true solar-system movement; features powered gcocentric and star-field overlay units; has an integrated calendar clock ephemeris; and includes overlays for demonstrating Keplerian laws and engineering calculations. It can be used to demonstrate interplanetary-trajectory requirements, to make preliminary measurements of spacecraft and planetary relationships and earth-to-spacecraft communications, and to teach courses in astronomy and celestial navigation in universities, observatories, etc.
Key number 339

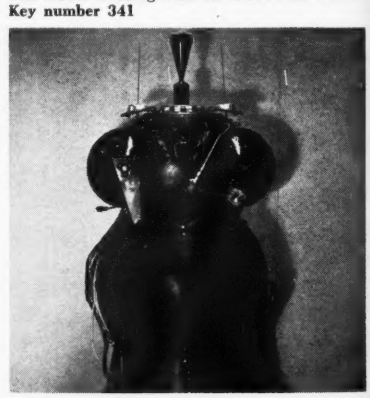
SILICA FIBERS AND FABRICS
Sil-Temp Div. of Haveg Industries, Wilmington, Del.
Booth Number 432

Silica fibers and fabrics have a melting point of over 3000 F and a high melt viscosity, and have good ion exchange properties, high surface area, and excellent quality control. Offered in a wide variety of fiber and fabric forms, they are presently in use as ablative reinforcing filler for missile nose cones and exit cones, high-temperature filtration, and medium insulating blankets for dielectric brazing. Future applications will include corrosion resistant reinforcing filler for plastics, high-temperature insulation, electrical insulation, and catalyst support.
Key number 340



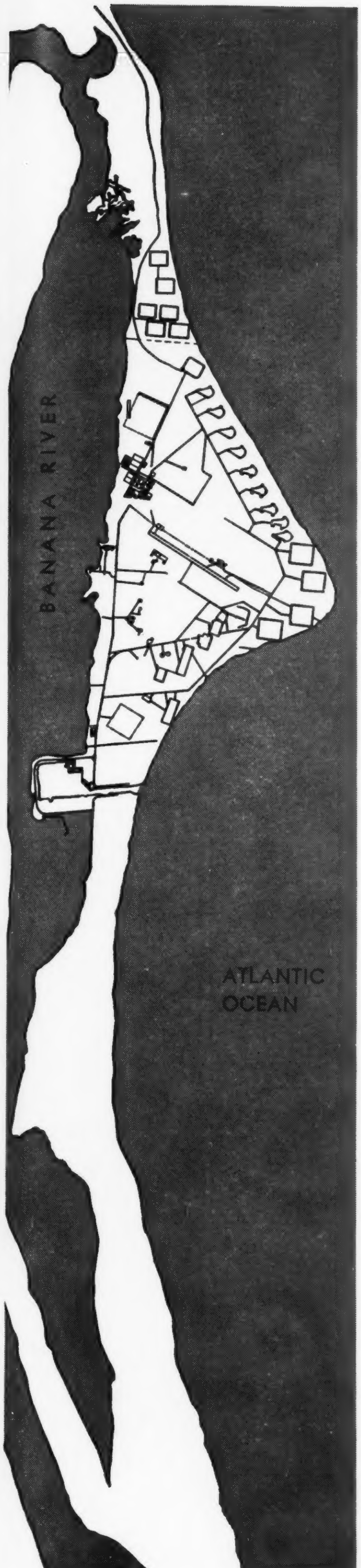
MOON-BASE MODEL
Space & Information Systems Div., North American Aviation, Los Angeles, Calif.
Booth Number 126

Exhibit model shows several stages of a proposed moon base from the earliest stage, when man's primary concern will be how to stay alive and function, to an advanced stage in which there will be various scientific laboratories. The model is being used for moon-base studies.
Key number 341



DEEP-SPACE PROPULSION SYSTEM
Space Technology Laboratories, Inc., Los Angeles, Calif.
Booth Number 104

Shown above is the first U.S.-built rocket engine-monopropellant system—designed to operate on a payload in deep space. The system can be incorporated as an integral part of a spacecraft or payload, can be turned on and off as needed by command signals, and can be operated in space many months after launch. The simplicity of the propulsion system results from the use of hydrazine as a monopropellant. Explosive-actuated single-motion valves control the flow from a gas pressurized propellant tank. The monopropellant unit was originally used on the Atlas-Able-5 payloads. Data from the Able-5A lunar probe showed that the monopropellant engine started and operated satisfactorily at 440 mi. altitude.
Key number 342



"INTERDICT"

Silencing the Skies at Canaveral

...and what it means to you

Cape Canaveral, a serious r-f interference problem, and a group of experienced Capehart engineers. This was one salient phase in the operation we call "INTERDICT," for Interference Detection and Interdiction by Countermeasures Team. The exact nature and reason for this operation, and the engineering service that is now available to all r-f installations, comprise our story...

You probably already know of the r-f interference experienced at the Cape: the large number of radiating and receiving equipments there were creating undesirable field conditions. Origin of these conditions was unknown. Capehart's engineers were asked to analyze all the site's r-f sources—radars, telemetry links, communications equipment, etc.—and to predict and determine the interference sources. What they found is now history. Many of the spurious signals stemmed from higher harmonics of radar and communications systems. Once these had been defined and located, and other sources of rfi also isolated, the engineers of INTERDICT recommended ways to still the noise, so that the skies over Canaveral could be silenced.

Next: Vandenberg. After their mission at Cape Canaveral, the Capehart engineers were called to Vandenberg Air Force Base. Once again, r-f radiation was causing interference and hazard problems. Once again, the Capehart INTERDICT team went to work: performed field measurements, analyzed spurious signals for carrier frequency and source, analyzed instrumentation and all r-f equipments functioning at Vandenberg. As a result of Capehart's recommendations and countermeasures, the noise could be silenced at Vandenberg, too.

If you have site problems or r-f interference on any military or industrial communications-electronics equipments, the engineers from Operation INTERDICT are at your service. Their background in this field is unparalleled, and their experience and knowledge of all current types of equipment can now be offered to all. This is the first such service we know of, and we're proud to make it available.

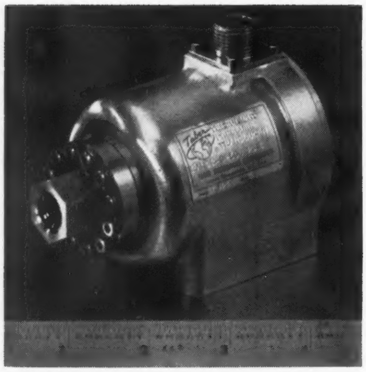
Note: As you well know, interference and noise can come from a variety of sources. Spurious transmitter and receiver signals are close to inevitable in electronics installations of any complexity. Our function is to determine what is interfering with what, and to take the correct remedial action. We also perform diagnoses as to possible electromagnetic radiation hazards to personnel, squibs, ammo or fuel, and suggest the proper remedies for these hazards.

In short, Capehart's INTERDICT service is performed in compliance with all applicable MIL Specifications and systems requirements. INTERDICT, under the direction of Dr. Joseph H. Vogelman, offers you complete, world-wide, packaged services for the prediction, detection and elimination of r-f interference, personnel and material hazards. To learn more about these services contact:

Capehart® CORPORATION

INTERDICT GROUP, Dept. P, CAPEHART CORPORATION
87-46 123rd Street, Richmond Hill 18, New York • HIckory 1-4400

Key number 84



PRESSURE TRANSDUCER

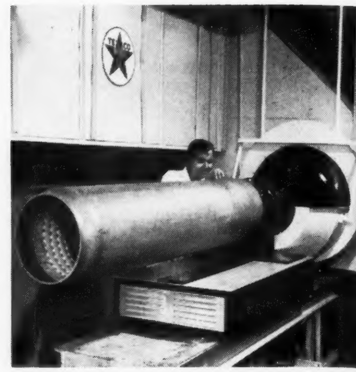
Taber Instrument Corp., Aerospace Electronic Div., Tonawanda, N.Y.
Booth Number 233

Model 185/290-2 is a new development in the Taber line of bonded strain gage pressure transducers. This transducer converts variations in line pressure into a measurable electrical signal with an accuracy of 0.25% of the true pressure. It requires an unregulated input power source of +26 to +32 v D.C. at 45 milliamps. The unit has a full-scale output voltage of 0 to 5 v across a 100 K ohm load. The instrument is designed and manufactured to withstand severe accelerations and vibrations such as encountered during missile and rocket flights. High overload capacity is built into all teleflight instruments. Applications of 300% of rated full-scale pressure will not damage the instrument or necessitate recalibration. Today pressure transducers are primarily used in the missile and rocket industry to provide accurate pressure measurements of fuels and of jet and rocket engine performance. Taber transducers have also achieved wide usage in the chemical and steel industries and in many other phases of manufacturing where accurate pressure measurement and control is required.
Key number 343

AEROSOL COATINGS

Tempil® Corp., 132 West 22 St., New York, N.Y.
Booth Number 182

The newly developed aersol Tempilaqs⁰ cover the interval 650 to 1000 F, and make 44 systematically spaced temperature ratings available presently in aerosol form—spanning the range 100 to 1000 F. Applications include nondestructive testing of honeycomb panels, monitoring the operating temperatures of reaction vessels, fabrication of massive structures, heating, etc. While Tempilaqs⁰ for temperatures above 1000 F are presently available in standard glass bottle packaging only, research is being continued to perfect aersol packaged Tempilaq⁰ in the higher temperature range to 2500 F.
Key number 344



TEI AIR-TURBOROCKET

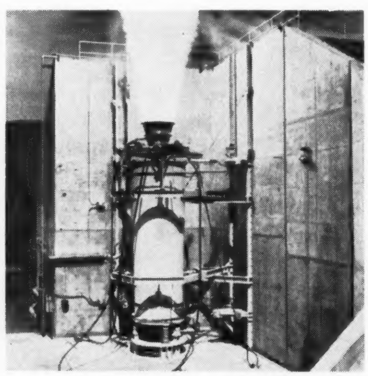
Texaco Experiment, Inc., Richmond, Va.
Booth Number 580

TEI originated and is currently developing a series of air-turborockets for missile propulsion systems. The mixed-cycle engines combine liquid-rocket thrust/weight ratios with turbojet fuel economy and appear very attractive for certain space applications. The ATR cycle is based on dual use of the propellant. The first reaction is in a rocket chamber to provide turbine working fluid. The turbine drives a compressor to deliver air to the burner. In turn, the turbine exhaust products form the air-stage fuel, adding heat to the exhaust jet. The unique characteristics of the ATR make it particularly interesting as an air-breathing substitute for conventional rocket boosters. Major reductions in missile or space-vehicle cost and weight, equivalent to doubling the impulse of present propellants, are expected. Design analyses on various propellants and missions are in progress.
Key number 345

ZIRCONIA FIBER

H. I. Thompson Fiber Glass Co., 1733 Cordova St., Los Angeles, Calif.
Booth Number 269

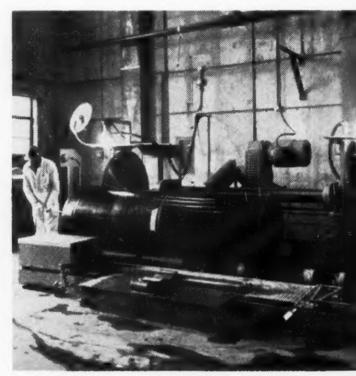
HITCO Zirconia Fiber is a high temperature resistant, high tensile strength, high modulus ceramic fiber. The cross section of the fiber is circular and the diameter is in the range of 0.0002 to 0.0005 in. The fibers are composed of the nominal oxides and are relatively pure. HITCO Zirconia Fibers melt at temperatures above 4300 F. These fibers will fill the need for higher temperature resistant materials required because of recent developments in the rocket and missile field. They will be used for structural reinforcement and ablation materials when combined with high-temperature resin systems. Thermal and cryogenic insulation problems will be resolved by use of these fibers in a batt form. HITCO Zirconia Fibers are now available in either a wool or continuous form and will eventually be available in the form of a textile.
Key number 346



SEGMENTED SOLID MOTOR

United Technology Corp., A Subsidiary of United Aircraft Corp., Sunnyvale, Calif.
Booth Number 390

This first U.S. operational prototype of a booster-size, segmented, solid-propellant rocket motor, successfully test-fired Aug. 5, 1961, is the forerunner of boosters of 3 million lb of thrust. When clustered, they will produce powerplants with energy of 25 million lb of thrust. The motor gives 250,000 lb of thrust for 80 sec. It utilized for the first time lightweight steel casing of exact flight design, and successfully passed first full-scale test of a prototype propellant charge of thickness required for larger booster motors. These booster rocket motors can be used for lifting huge payloads into orbit around the earth or sending them on deep-space missions.
Key number 347



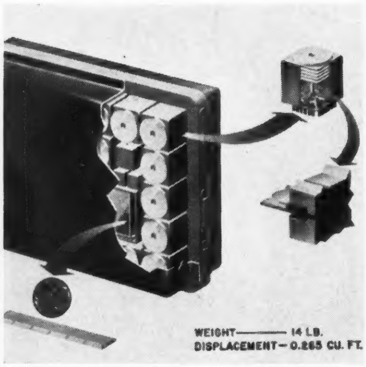
SOLID PROPELLANT GRAIN

U.S. Naval Propellant Plant, Indian Head, Md.
Booth Number 552

Casting is the process by which the majority of composite and double-base solid propellant grains are made today. The technique lends itself to the wide variety of ingredient combinations and mathematically determined grain configurations which are used in today's missiles. In the photo above, a double-base propellant grain for the Talos missile is shown being cleaned of propellant scrap prior to being cut to length for loading in a Talos booster motor. For saftey's sake, the actual sawing operation is done by remote control and the saw blade is cooled with water to prevent friction from igniting the grain. Missiles for which NPP produces similar grains include Bullpup, Boar, Deacon, Terrier, Snark, and Weapon Alfa. Scale models of the second-stage for Polaris are also produced by this process at NPP.
Key number 348

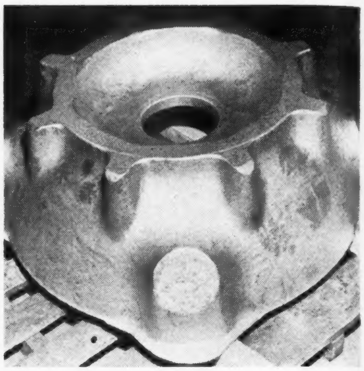
CRYOGENIC MASS FLOWMETER
Waugh Engineering Div., The Foxboro Co., Van Nuys, Calif.
Booth Number 220

This new mass flowmeter is the first developed specifically for cryogenic fluids. It is adaptable to liquid fluorine, or other liquefied gases, and is equally effective with gases, liquids, or gas-liquid mixtures at higher temperatures. The flowmeter operates on a constant angular momentum principle and embodies a unique new hysteresis drive concept which maintains accuracy under heavy vibration and at extreme temperatures. A digital signal output permits highest accuracy in both flow rate and total quantity measurements. Power frequency and voltage may vary widely without affecting flowmeter accuracy. The mass flowmeter is used for testing liquid-hydrogen-fueled rocket engines and may also be used for tests of other propulsion system elements using wide variety of fluids.
Key number 349



MOLECULAR COMPUTER
Westinghouse Air Arm Div., P.O. Box 746, Baltimore, Md.
Booth Number 405

Mol-E-Com, a molecularized computer, is one tenth the size of a transistorized computer with equal capabilities and added reliability. Conventional components are replaced by solid state functional electronic blocks which will perform the functions of switching, amplification, or other logic functions. Mol-E-Com weighs less than 15 lb and one third of a cubic foot. Easy serviceability is an additional feature. The molecular components will be located for easy access for rapid replacement if required. Now in development, the projected increase in reliability and decrease in size and weight makes the computer suitable for a variety of space missions where payload space is at a premium.
Key number 350



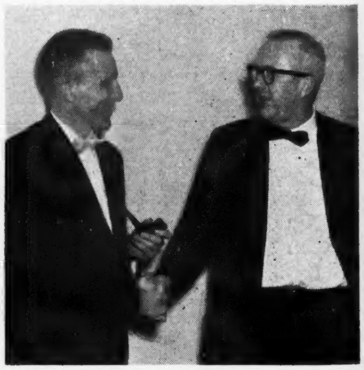
COLUMBIUM FORGING
Wyman-Gordon Co.,
Booth Number 252

Typical of closed-die forgings being produced by Wyman-Gordon from the difficult-to-work refractory metals and high-temperature nickel-bearing alloys is this columbium component intended for use at operating temperatures in the 1700–2000 F range. It represents largest known forging of this metal, made from an ingot 15 in. in diam and 26 in. long, weighing 1300 lb. The ingot was produced by electron-beam melting, followed by duplex-vacuum-arc melting to remove impurities. The forging procedure involved protection of the metal to prevent absorption of atmospheric gases at forging temperatures in the 2100–2250 F range. Columbium, which has a melting point of 4379 F, is extremely stiff during working and thus utilizes the forging capacity of the 50,000-ton closed-die forging press at the USAF-leased North Grafton plant. Other materials in regular production by Wyman-Gordon include beryllium, titanium alloys, molybdenum, tungsten, tantalum, alloy and stainless steels, and the light alloys, including magnesium.
Key number 351

ARS Charters Stanford Student Chapter

The first president of the new ARS Stanford Univ. Student Chapter, Peter Zimmerman, left, receives the charter from ARS Board member and past ARS president Howard Seifert in ceremonies at a recent ARS Northern California Section dinner meeting. In the foreground, George Edwards, vice-president of the Northern California Section.

Spacetronautic Speaker



The featured speaker at the ARS Chicago Section's annual Spacetronautic Banquet this year was John P. Marbarger, right, director of the Univ. of Illinois Aeromedical Lab. Shown being welcomed by Chicago Section President C. C. Miesse, Dr. Marbarger discussed the roles of biology and medicine in space exploration.

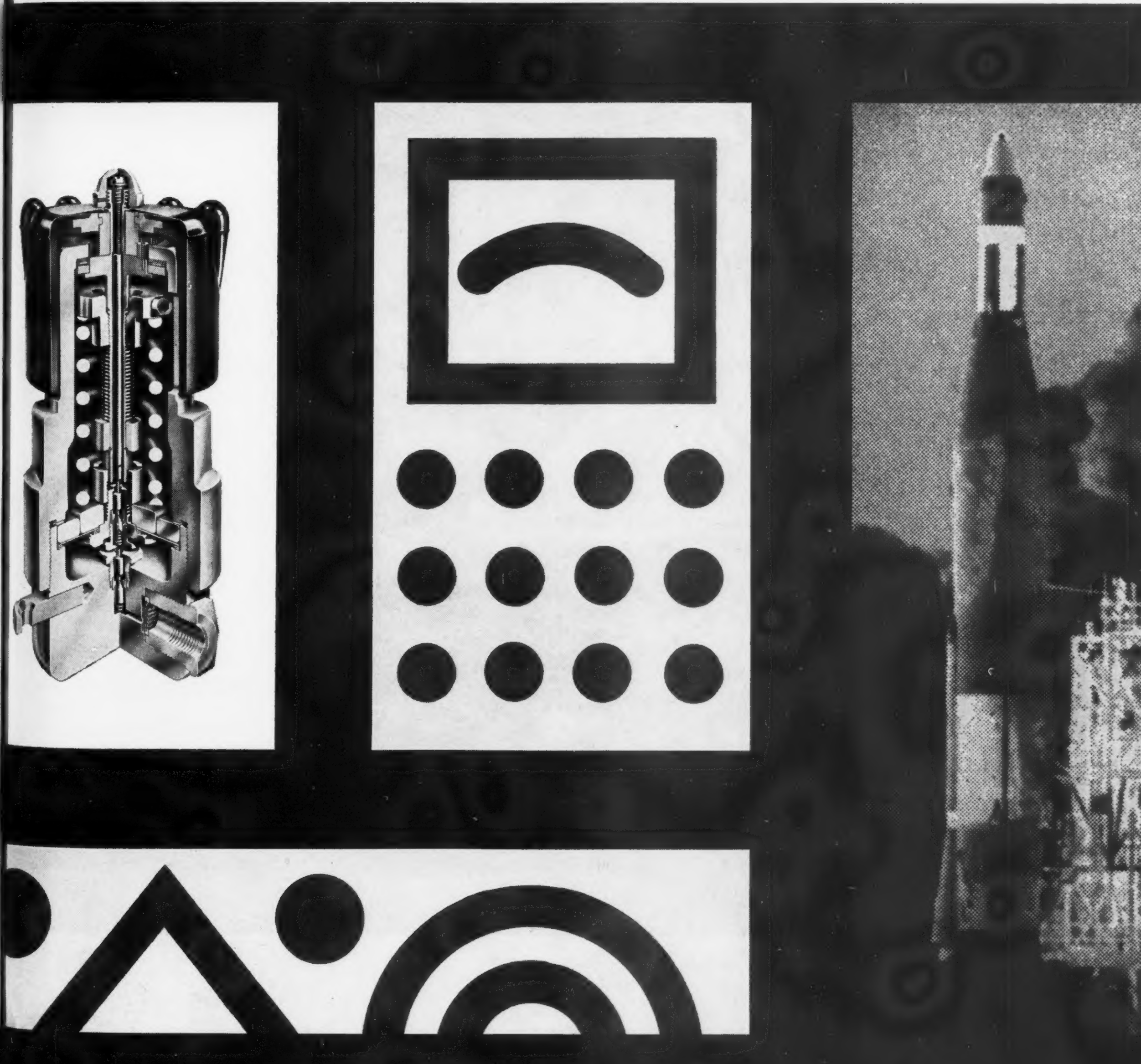
SOLID RELIABILITY FOR SPACE RESEARCH

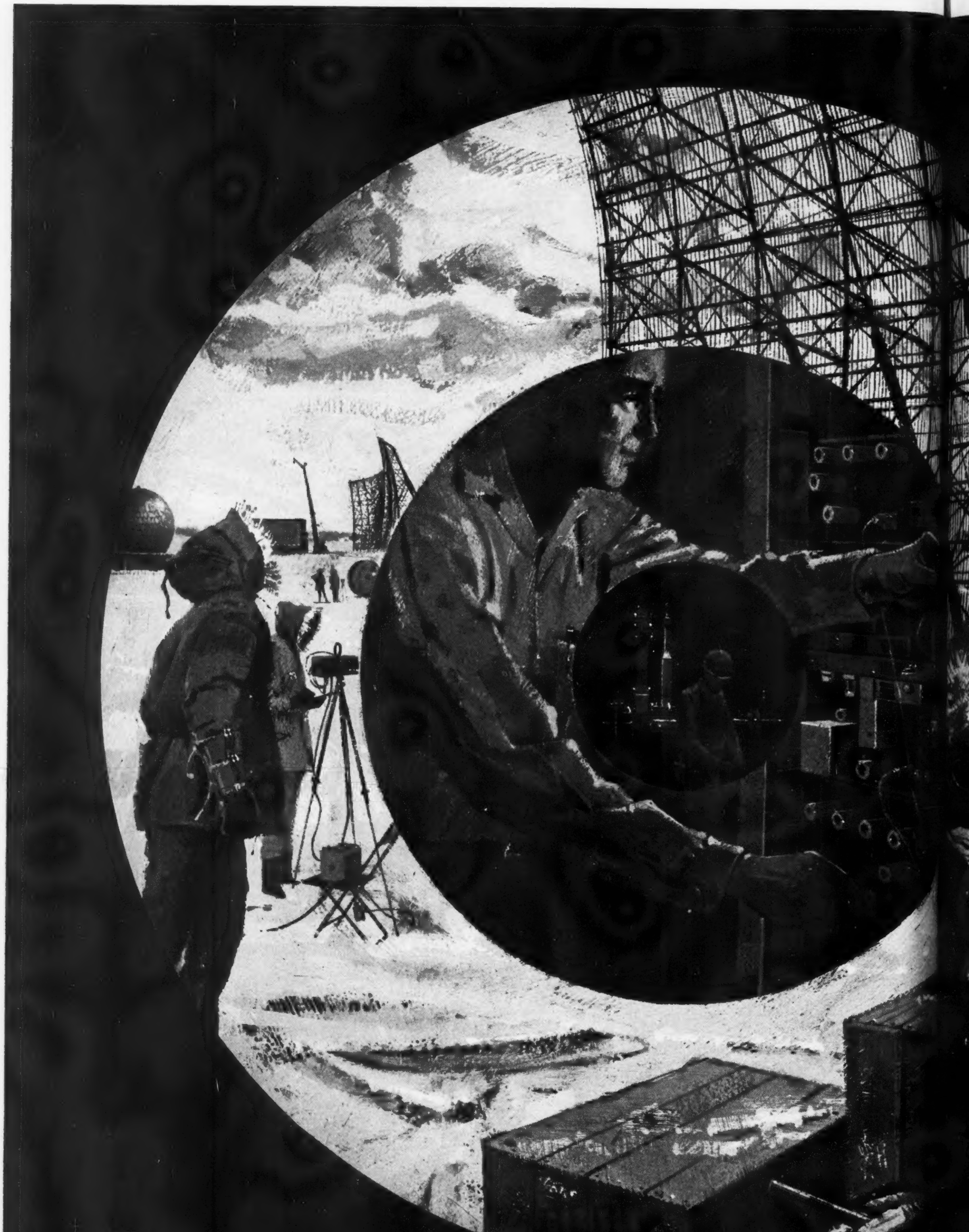
In 1947—Thiokol, working in cooperation with JPL, helped devel techniques for case bonding that made possible today's so fueled giants. Since that time... from the RV-A-10 engine whi proved feasability of scale-up and the Falcon which introduc mass production to the rocket industry, to the huge booster f Minuteman and the high thrust power of Nike Zeus... Thio history is one of innovations marking progress in rocket prop sion. □ Thiokol retro-rockets contributed in large measure to t

BENCHMARKS in the

THIOKOL CHEMICAL CORPORATION □ Bristol. Penna., Rocket Operations Center: Ogden, Uta

Key number 29 ⟶





Catalyst for Progress

(CONTINUED FROM PAGE 43)

Western or neutral newsman has ever been admitted to the Soviet launching zone, while observers of any nationality can camp on the beach at Cape Canaveral if they like, has not gone unnoticed by the people of the world.

I receive many letters inquiring about our progress. Most, fortunately, ask why we don't move faster. My answer is that we can, and we have started to do so.

On the other hand a few citizens ask why the United States is spending hundreds of millions, and planning to spend billions, on the exploration of space. Why not put it into cancer research, our hard-pressed education system, slum clearance? Who wants to go to the moon anyway? My answer is that we can attain the moon, and unfold the fascinating secrets of deep space, and do all those other necessary things as well.

No organism—whether it is an individual, a nation, a civilization—ever stands still. We either drive ahead or slide back. The one unchanging law is that everything changes. Wherever man stands on earth, the path of progress is up.

The Russians have been first with the spectacular space shots. They may hold this lead for some time. But when it comes to putting men on the moon and returning them safely to earth, we have a chance to be first, and we intend to win that race.

Some of our space shots have already provided important benefits to mankind. For example, our first two Tiros satellites are telecasting global weather information that the United States relays to any nation requesting the service, including the Soviet Union and its satellites. A hundred nations, including the USSR, have been invited to participate in an international weather workshop in Washington, November 13–22, where their meteorologists will be briefed on the most efficient means of utilizing the Tiros data.

Soon we intend to put up a number of more sophisticated Tiros satellites in orbits that will literally entwine the earth. In lives and property saved from hurricanes and monsoons, in weather data collected of use to agriculture, the Tiros program is going to pay for itself over and over again.

Another of our utility-type projects, the communications satellite, will soon extend its benefits around the globe, including those underdeveloped countries in which communications are slow, sparse, and difficult. This satellite will not only bring people closer together through voice and records, but will provide them with instant transocean television. Plans are now underway for Voice of America television transmissions to national networks and Eurovision on the other side of the Atlantic. And these satellites will be two-way streets for the exchange of news and information. It will, for instance, be possible for people in New York and San Francisco and Ottawa to see and hear the British Prime Minister as he delivers an important speech in London.

This is only the beginning—the dawn of an age. The greatest achievements in space are yet to come. What they will be, no man can certainly say. Fifty years ago, the Wright brothers could not have envisioned the supersonic jet plane. Ten years ago, I would have been viewed as exceedingly eccentric had I suggested, in the United States Senate, establishment of a base on the moon.

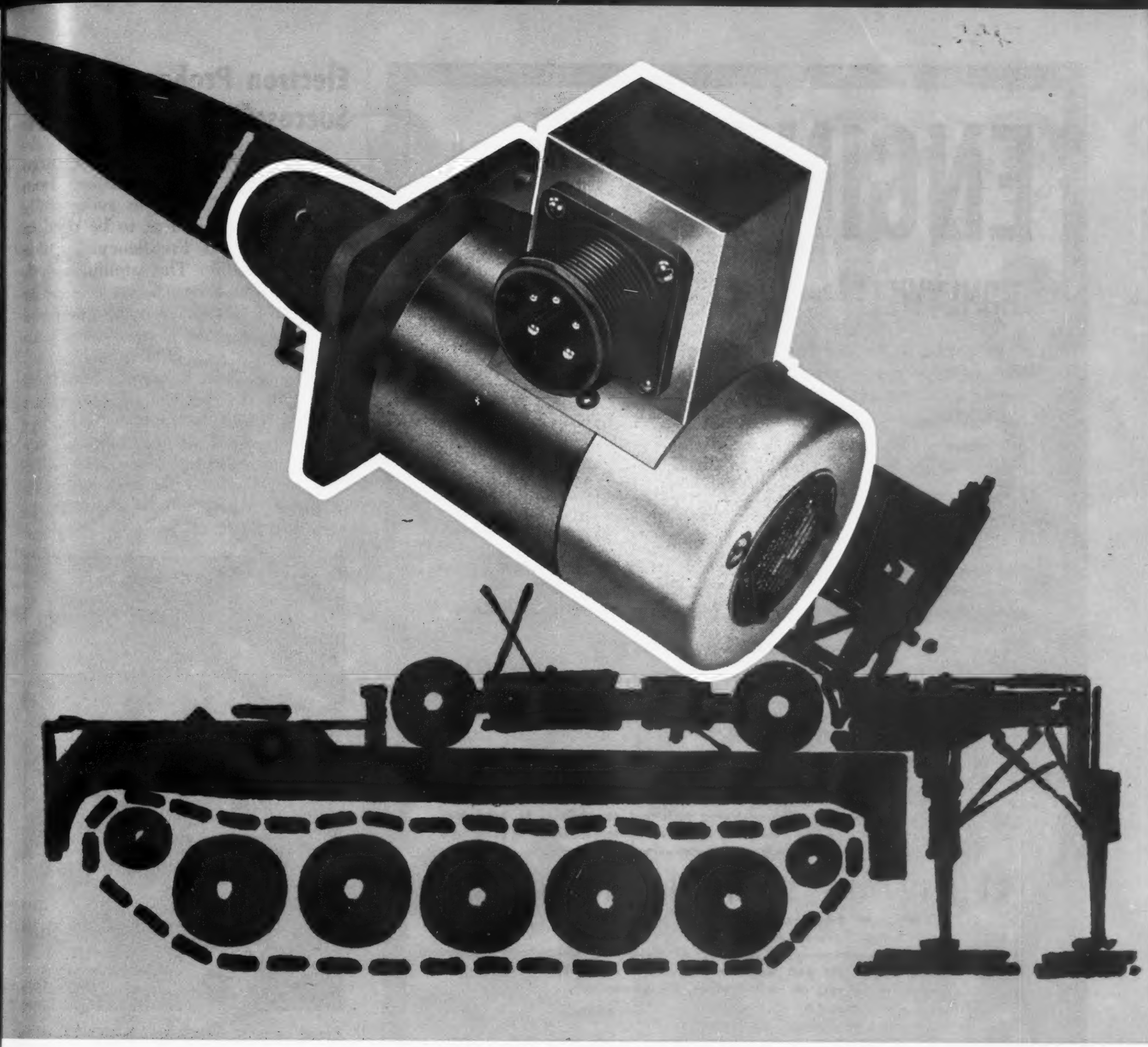
Today I am convinced that there is almost nothing that man can imagine that he cannot attain. This may be a "time of troubles," but I am happy to live in this time. ♦♦

NASA Receives Presidential Safety Award for 1960

The National Aeronautics and Space Administration, giving the lie to the reputation of rocketry as being exceptionally hazardous, recently received the President's Safety Award for 1960—one of three given annually to departments or independent agencies of the federal government for the best safety record during the year. The AEC also received one of the awards. To be eligible for the award, an agency must show a decline in its accident rate and the severity of disabling injuries. The agency is then rated on its whole accident-prevention program. NASA was rated 95% perfect.

Robert Gross of Lockheed Dies

Robert E. Gross, president of Lockheed Aircraft Corp., died of cancer of the pancreas at the age of 64 years old on September 3. Under Gross' direction and vision, Lockheed was developed from a $40,000 concern, the price he purchased it at in 1932, to the $548-million organization it is today. He was the builder of the first pressurized-cabin plane, the Hudson bomber, and the Electra, the first American plane to employ jet power for commercial aviation.



Electron Probe Successfully Flight Tested

An Aerolab Development Co. Argo D-4 sounding rocket launched from Wallops Island in June successfully tested some equipment to be used in the S-48 Fixed Frequency Topside Sounder satellite. The satellite, scheduled for launch in a Scout vehicle by NASA in late 1962, was designed and built by the Airborne Instruments Laboratory Div. of Cutler-Hammer and the National Bureau of Standards Central Radio Propagation Laboratory under a NASA contract.

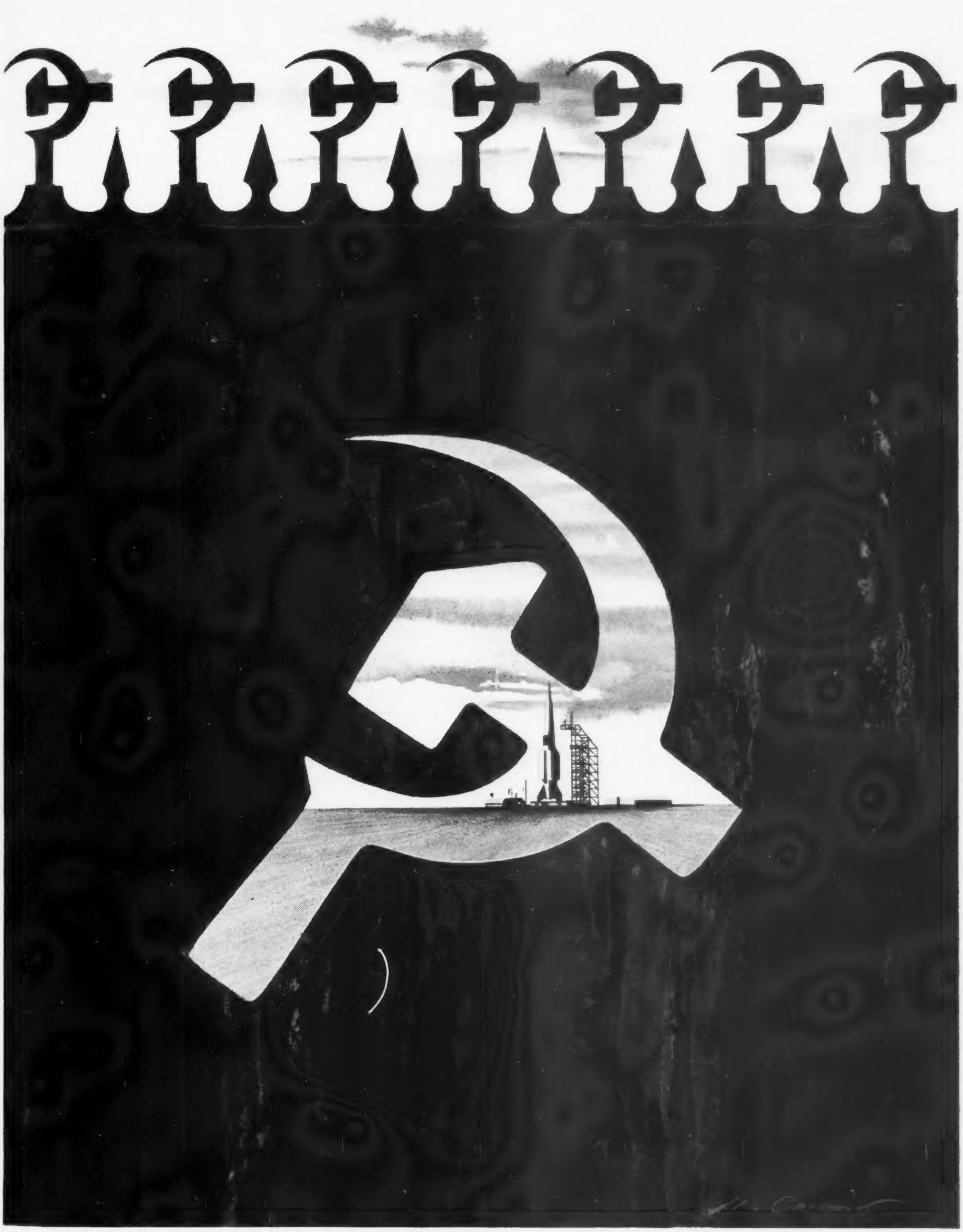
The payload of the satellite, designed to measure ionospheric electron density above the peak ionization of the F_2 layer, will be about 24 in. high and 24 in. wide.

Artist's rendering of S-48 Topside Sounder satellite payload

Exchange Students Sought For Studies in USSR

The Inter-University Committee on Travel Grants is seeking inquiries and applications from American citizens under 40 who are graduate students, post-doctoral researchers, or faculty members desiring to spend all or part of the 1962–63 academic year in study and research in the Soviet Union, as part of the academic exchange between the U.S. and USSR. Knowledge of Russian is required, and periods of study between one semester and 15 months can be arranged.

Additional information and applications may be obtained from Stephen Viederman, Deputy Chairman, IUCTG, 719 Ballantine Hall, Indiana Univ., Bloomington, Ind.



BEHIND THIS CURTAIN HIDE THE ONLY ICBMs NOT WATCHED BY KIN TEL CLOSED CIRCUIT TV SYSTEMS

For full information on Kin Tel closed circuit TV, write direct.
Representatives in all major cities.
5725 Kearny Villa Road • San Diego 11, California • Phone BRowning 7-6700
Key number 93

COHU
ELECTRONICS, INC
KIN TEL DIVISION

[1] CAPE CANAVERAL, Fla., Sept. 21, 1960--United States Air Force Officers and Airmen of the Air Force Ballistic Missile Division (ARDC) today successfully launched a four stage solid fuel Blue Scout Junior research rocket high over the Atlantic Missile Range. [2] CAPE CANAVERAL, Fla., Nov. 8, 1960--The Air Force Ballistic Missile Division today test launched for the second time a four stage, solid fuel, Blue Scout Junior research rocket. Today's firing is part of the Air Force program to launch vitally needed scientific space packages on a regularly scheduled basis. [3] CAPE CANAVERAL, Fla., Jan. 7, 1961--The Air Force today launched the largest solid fueled Ballistic vehicle to date at the Atlantic Missile Range. Carried for the first time aboard the Blue Scout test vehicle was a guidance system operative during all three stages. [4] CAPE CANAVERAL, Fla., Mar. 3, 1961--An Air Force Blue Scout rocket today lofted a 172 pound payload approximately 1,580 statute miles into space. The payload was designed to make detailed radiation measurements as it travelled through the lower edges of the Van Allen Belt. [5] CAPE CANAVERAL, Fla., April 12, 1961--Development Flight No. 5 of the Blue Scout was successfully launched today, the Air Force announced. Carrying seven experiments, three bursts of seven flares were fired and tracked by a camera system from Cape Canaveral. [6] CAPE CANAVERAL, Fla., May 10, 1961--A range safety officer made a $500,000 decision yesterday and ordered destruction of a Blue Scout Junior rocket seconds after it was launched. Yesterday's failure was only the second for the Blue Scout in six firings.

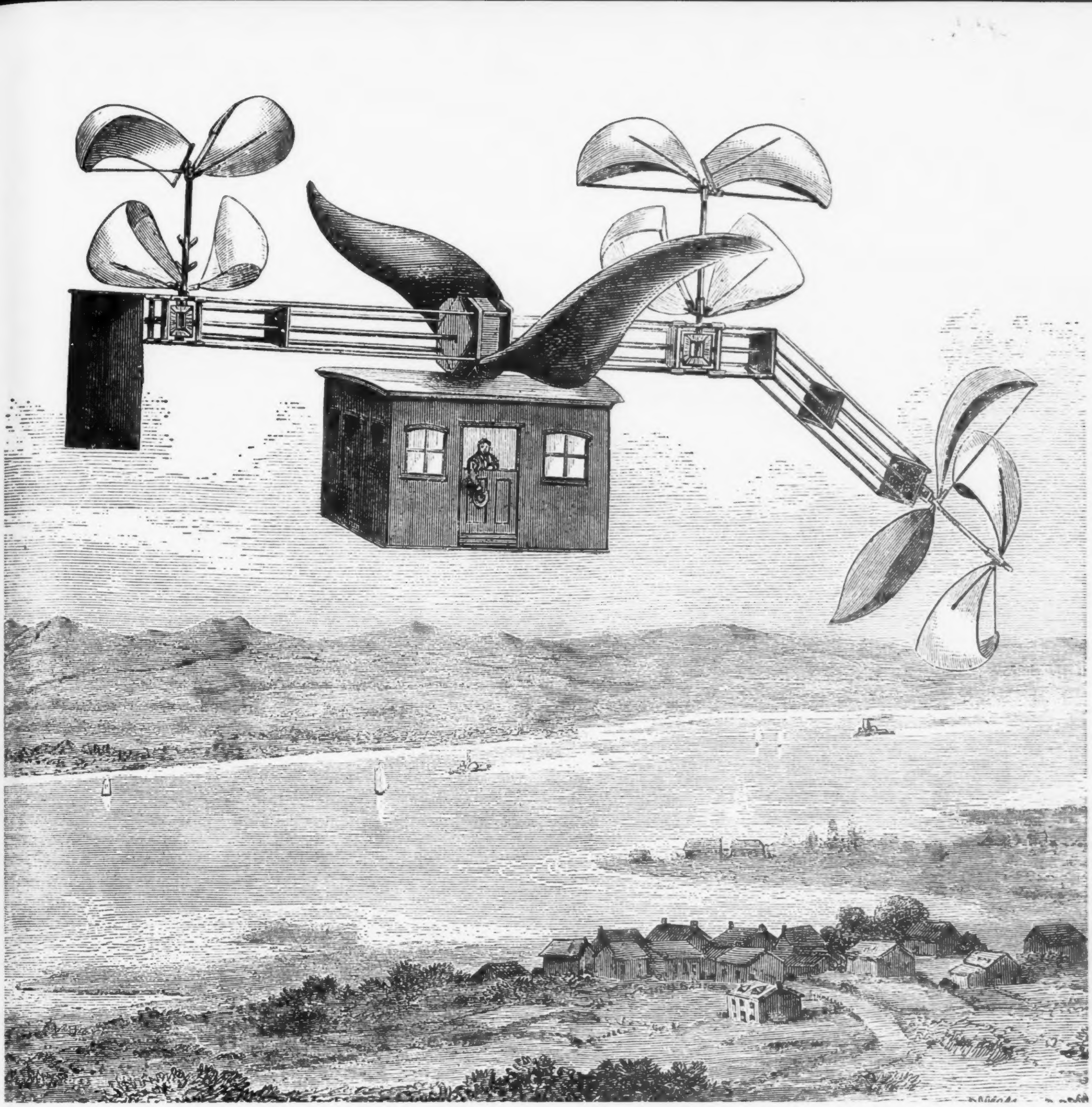
The reliability of the Air Force Blue Scout is one of the highest in the industry. Aeronutronic is system engineer, payload and test contractor on Blue Scout. Additional information is available upon request.

Ford AERONUTRONIC

AERONUTRONIC DIVISION Ford Motor Company, DEFENSE PRODUCTS GROUP

NEWPORT BEACH, CALIFORNIA

Key number 94



ARS at 31

(CONTINUED FROM PAGE 71)

the Society had started "a survey of the entire field of information relating to interplanetary travel," and disclosed the names of prominent new members, among them Captain Sir Hubert Wilkins, the explorer.

It discussed a then recent address by John Q. Stewart, the Princeton astronomer and physicist, who had concluded that man would be able to get to the moon about the year 2050, forecasting that the trip would be made in a spherical metal vessel 110 ft in diameter, propelled on the rocket principle by a "dozen or more cannon." The *Bulletin* further reported a somewhat more optimistic forecast by Robert Esnault-Pelterie, the French airplane manufacturer and author of "L'Astronautique," to the effect that a trip to the moon would be possible in 15 years—that is, by 1945. Dr. Esnault-Pelterie pointed out, however, that financial backing would be the *sine qua non* of such a venture "since experiments costing perhaps $2 million would have to be made first." Liquid oxygen and liquid hydrogen were suggested as the propellants.

Understandably impatient with the rate at which others were developing the rocket, the Society in May 1931 formed an Experimental Committee which began a research and development program of its own. The first of the Committee's rockets was patterned generally after the "two-stick repulsor" rocket of the German Verein für Raumschiffahrt. Subsequently the experimental group branched out a little, producing a "concentric-tank" rocket with the gasoline tank enclosed inside the liquid-oxygen tank, a "multinozzle" rocket with four nozzles projecting from a single motor, and some others.

Though a couple of these experimental rockets performed rather well, considering the then state of the art, their principal utility was to convince the Committee that building complete rockets without first developing reliable components was fools' business. The Society consequently constructed its first "proving stand," and embarked on a long series of liquid-motor tests, which culminated in the development of James Wyld's highly successful regenerative motor and led in 1941 to the formation of Reaction Motors, Inc. (now a division of Thiokol) by four members of the Committee, with the Wyld motor as their first offering.

On the organizational front, things were progressing, too. The early membership of the Society soon grew to more than 100, with some notable

figures joining the ranks. These new supporters included Alexander Klemin, head of the Guggenheim School for Aeronautics at New York Univ.; John O. Chesley, in charge of new developments for the Aluminum Co. of America; George V. Slottman, later vice-president of the Air Reduction Co.; and James M. Kimball, of the U.S. Weather Bureau. Robert H. Goddard was also an early joiner, and at the time of his death in 1945 was a member of the Board of Directors.

The subsequent growth of the Society was slow, and its future remained insecure until about 1944, when two things of importance happened. One was the arrival of the first German V-2 rockets in London, which electrified the world and convinced many doubters that the age of rocketry had come at last. The other was the employment of Agnes "Billie" Slade as secretary to the Society, at first on an occasional basis and after March 1945 on a more regular one. Mrs. Slade was the Society's first paid employe; she was at one and the same time a symbol of its growing affluence and importance, and a powerful prime mover toward its greater growth.

When Mrs. Slade took over the "office," a small, airless, windowless cubicle in a midtown New York building, the Society had a list of some 1500 alleged members, many of whom had forgotten to pay their dues. Billie promptly adopted an important rule of organizational policy: No pay, no membership. This edict reduced the membership to 237. Backed by an approving group of officers and directors, she then inaugurated the program of promotional, advertising, and membership activities which have since continued with such success.

She also brought into the organization a powerful new force in the person of James Harford, now executive secretary of the Society. Jim put fresh energy behind the publications program, organized a nationwide advertising network to help pay for the growing magazines, introduced informative exhibits into the matrix of the national meetings, and sought new and better avenues through which the Society could serve the needs of astronautics and the nation, culminating now in the SPACE FLIGHT REPORT TO THE NATION.

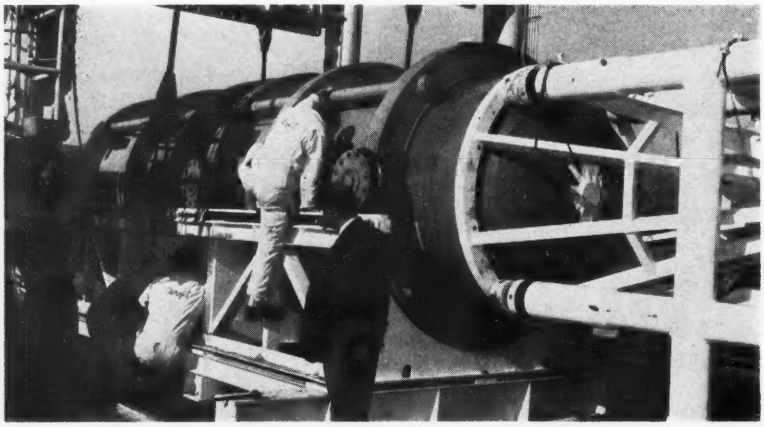
Membership Growth

By 1952, membership of the society had climbed back up to the 1500 mark—all paid up this time. By 1955, the membership had grown to 4000. The ARS had now bcome the fastest-growing major technical society in the country, if not the world. When Mrs. Slade retired in the summer of 1960, the membership had reached 14,500; as of October 1 this year, it totals 19,000, and it will exceed 20,500 before the end of 1961.

Mere numbers, of course, mean little; who the members are is what counts. The American Rocket Society today enrolls a greater number of the leaders of American rocketry and space flight than any other society. Devoted entirely to the advancement of astronautics, ARS, through its meetings, publications, and Technical Committees, probably exerts greater impact on this swiftly developing field than any other technical organization anywhere.

In 31 years, the Society has seen astronautics emerge into full growth. Arising from a germinal idea all but smothered in swamps of skepticism, inertia, and ignorance, it has become one of the most exciting and dominating forces of our times.

Esnault-Pelterie and John Q. Stewart were not wrong in their forecasts of 31 years ago—just a little faulty on their timetables. It can safely be expected that the Society will continue to do its part to make their prophecies come true. ♦♦



New Frontiers for Solid Rockets

Two chamber segments of 25-ton sub-scale motor, largest segmented rocket ever tested, are mated in test bay prior to successful test firing by Aerojet. The 65-in.-diam motor developed 160,000 lb of thrust in the test.

Vacuum Chamber Components Hit the Road

If you were held up somewhat on the Ohio Turnpike recently, this may have been the reason. It's a three-truck convoy carrying components of a vacuum chamber built by Chicago Bridge and Iron Co. for NASA to the agency's Lewis Research Center at Cleveland. It constituted the largest cargo ever to travel the turnpike. The completed chamber, to be used for ion and plasma engine tests, will be 15 ft in diam and 82 ft long. Largest section shown here is a 26-ft door rising 12 ft above the highway.

INDEX TO ADVERTISERS

ADVERTISING REPRESENTATIVES

"Whither goest thou, and by what guidance?" spoke the great Persian astronomer, Nassir-Eddin Al Tusi to Marco Polo, as the Venetian announced his adventure to the Far East in 1271. The astronomer's advice was simple and direct: "Knowest thou the stars." What better advice for today's explorers? What better guidance system than knowledge itself, as we step off the earth's edge.

★ THE "COPERNICAN" PLANETARIUM BRINGS A MOVING UNIVERSE INDOORS

Before men explore space they must know where they're going and how to guide themselves. The "Copernican" teaches them by bringing alive the sciences of astronomy and celestial navigation. Orbital mechanics and body-to-body transfer can be calculated using the "Copernican" as a celestial analog computer. Mission pre-planning and briefing can be simplified and clarified. The "Copernican" brings the moving Universe into the classroom, lecture hall, and briefing room—under your exacting control.

★ See the "Copernican" Planetarium in action, "A.R.S. SPACE FLIGHT REPORT TO THE NATION," Oct. 9-15, New York City, Exhibit Sta. 202 (1st Fl.)

SCIENTIFIC INDUSTRIES, INCORPORATED

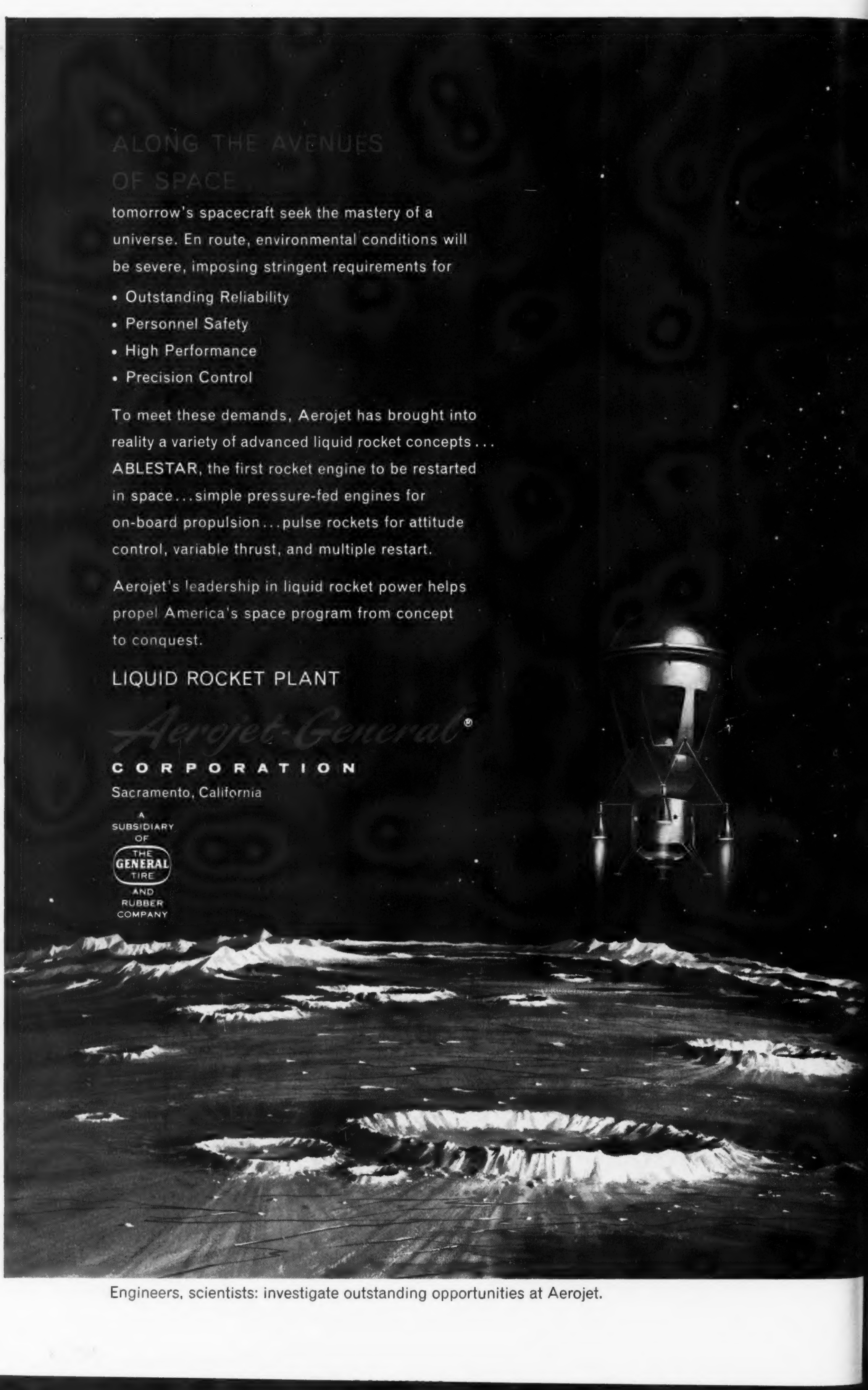
817 Victory Boulevard, Burbank, California

SOME USERS OF THE MUSSER "COPERNICAN" PLANETARIUM... Douglas Aircraft Company, Aero/Astrodynamics Section, Missiles and Space Systems (For demonstrating interplanetary trajectory requirements); Jet Propulsion Laboratories (For preliminary measurements of spacecraft and planetary relationships, and earth-to-spacecraft communications); American Museum-Hayden Planetarium. (For teaching 19 courses in astronomy and celestial navigation); Adler Planetarium and Astronomical Museum (For demonstrating solar system mechanics and movement of the night sky, in 5 or 6 public lectures daily.)

P.S. VISIT THE HUGHES AIRCRAFT COMPANY'S SPACE EXHIBIT AND SEE THE DYNAMIC PERFORMANCE OF THE MUSSER COPERNICAN PLANETARIUM

Exhibit #339 ARS Show

Key number 102


ALONG THE AVENUES
OF SPACE
tomorrow's spacecraft seek the mastery of a universe. En route, environmental conditions will be severe, imposing stringent requirements for
• Outstanding Reliability
• Personnel Safety
• High Performance
• Precision Control
To meet these demands, Aerojet has brought into reality a variety of advanced liquid rocket concepts ... ABLESTAR, the first rocket engine to be restarted in space ... simple pressure-fed engines for on-board propulsion ... pulse rockets for attitude control, variable thrust, and multiple restart.
Aerojet's leadership in liquid rocket power helps propel America's space program from concept to conquest.
LIQUID ROCKET PLANT
Aerojet-General®
CORPORATION
Sacramento, California
A SUBSIDIARY OF THE GENERAL TIRE AND RUBBER COMPANY